THE STORY
OF
ELECTRICITY

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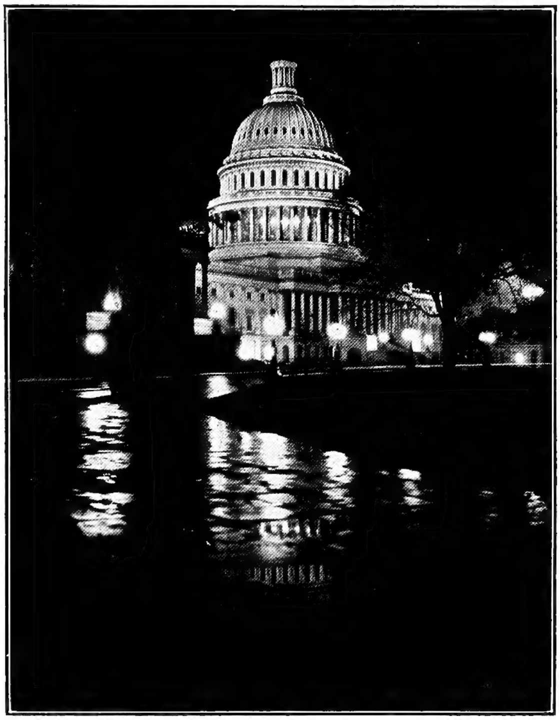
THE STORY OF ELECTRICITY

The Story of Electricity

VOLUME TWO



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THE STORY OF ELECTRICITY COMPANY

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THE STORY OF ELECTRICITY

VOLUME II

PREFACE

THE first volume of THE STORY OF ELECTRICITY was issued after a period of preparation so seriously extended by the Great War that at times during the struggle for world freedom it seemed that it might be impossible to carry a work of such magnitude to satisfactory completion.

The reception of that volume was so immediately hearty and eulogistic, the authors were encouraged to proceed with the unfinished task; and they now have the honor to submit Volume Two to the industry and profession of which it aims to be the contemporaneous record.

To the ordinary difficulties attendant on such an enterprise, have been added many problems due to the universal dislocation of life and society at this time. As civilization pulls itself together, there is a natural tendency to concentrate thought and energy upon the merely brute processes of reparation. But if there has been one lesson of the momentous years, it is that "the proper study of mankind is man" and that the teachings of history cannot be disregarded.

Never was there keener interest than today in history—racial, individual, political, industrial, and never was there an epoch or era upon which hereafter the attention of mankind will center more than that of the period these pages cover. It is the privilege of the present editors, under limitations that none know better than themselves, to deal with the electrical part of the story and that of the men who made it.

The production of this volume, and of its companion volume, One, has demonstrated the tendency of men who are engaged in the advancement of electrical science to put their shoulders to the wheel and help. To many and diverse interests—both personal and corporate—are due the thanks of those engaged in the gathering and assembling of the material for these volumes; in fact, without the cooperation and encouragement which have been extended, the work would have been impossible at the present time.

Volume II, in addition to illustrating various leading men in different sections of the field, undertakes to give something of the history and development of a considerable number of commercial organizations which are outstanding in the industry. The authors hope that the varied character of the volume will thus contain some element of interest to even the most casual reader.

The Story of Electricity is one which is constantly unfolding. Generally speaking, only the first pages have been turned. Material is being made into history with each day of each year and the authors can only hope that these volumes will occupy a place in the final history of one of the world's great industries.

T. COMMERFORD MARTIN

STEPHEN LEIDY COLES

New York, 1922

SUMMARY OF CHAPTERS

THE STORY OF ELECTRICITY

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CHAPTER I

THE STORY OF THE ARC LIGHT

THE arc was the first electric light and performed a very useful function in the early propaganda to educate the public in the uses of the new form of energy called "electricity." On the lecture platform and later as a street illuminant, the arc light afforded something tangible which the lay mind could grasp and which any one could see performing its predicted task. It actually "worked," although often accompanied by much sputtering and hissing. The only other artificial illuminant with which it could be compared for outdoor lighting was the gas jet, and the arc light was so overwhelmingly brilliant by comparison as to make a lasting and most favorable impression on those who saw it. Small communities, many of which had never known any form of street lighting, were especially impressed by the wonders of the arc light, and it was in many such places in the United States that the early installations gained a foothold. Until the incandescent lamp was introduced in commercial practice, the arc light reigned supreme, especially as an outdoor illuminant. The lamp itself went through many stages of development and was adapted for use on all forms of electric current. It served its purpose well and was most useful except in confined spaces where the heat of the arc was undesirable. By a curious turn of progress and events, the gas-filled incandescent lamp is now rapidly replacing the arc lamp, and the latter is finding its greatest usefulness in the form of the searchlight which is now being produced in size and power undreamed of a few years ago. However, there still remain many services which the arc lamp best performs and it is by no means defunct or out of date or likely to be discarded.

The fundamental electric arc, as distinguished from the arc lamp or the arc light, may be produced by bringing into contact and then slightly separating the two terminals from any sufficiently powerful source of electrical energy. The first arc was formed by attaching carbon pencils to the terminal wires of a large number of voltaic cells, bringing them into contact with each other and then slightly pulling them apart. The electric discharge thus created between the carbon points was called the electric "arch" or arc. In 1801 Sir Humphry Davy, the English scientist, produced and studied this phenomenon and, therefore, he is credited with being the basic inventor of the arc light; but it is better to speak of him as the discoverer of the phenomenon of the arc itself. In 1808 the Royal Institution, of London, provided for Davy a battery of 2,000 voltaic cells as a source of electrical energy with which he performed a number of public experiments on a large scale with the electric arc. In his early experiments Davy employed rods of wood charcoal which were heated and plunged into mercury to make them better conductors of the electric current.

In most forms of arc lamp used for illuminating purposes, rods of hard gra-

phitic carbon are employed, although in some cases one or both carbons have been replaced by metallic rods. When carbon rods or pencils are brought into contact

The Old and the New. Gas to Electricity

and then slightly separated and a continuous current at a pressure as low as sixty volts is passed through them, no discharge is visible, but owing to the rise in the resistance of the contact, and the heat thus developed, the space between the ends of the carbons is immediately filled with a luminous vapor or flame and the tips of the carbons become highly incandescent, and are consumed.

If the carbons are placed in a horizontal position the luminous vapor takes the form of an arch springing from one tip to the other, thus giving origin to the name "arc." The characteristic appearance of the arc varies, depending upon whether a continuous or an alternating current is used and whether the arc is formed in the open air or in a confined space from which the oxygen of the air is excluded. When the electric arcs are formed between metallic rods or surfaces, the color of the arc flame varies greatly according to the nature of the metal used. If an alternating current of very high voltage is used as the source of electrical energy, it produces a distinctly audible humming sound and can be drawn out to a great length, without rupture, and will form a flickering lambent flame.

A rough classification of electric arcs includes the continuous current arc which is produced by an electric current always flowing in the same direction; the alternating current arc produced by a periodically reversed current; the open arc in which the carbons, or other material used, are freely exposed to the air; the enclosed arc in which the carbons are placed inside a glass globe; the chemical or flame arc which makes use of carbons impregnated with various salts for the purpose of coloring or increasing the light; the pure carbon arc; the arcs using metallic or oxide electrodes, such as magnetite. The location of the carbons in the arc lamp may be in a vertical line, one above the other, or at an angle so as to throw the light down. All arcs throw the light in more than one direction, no matter what is the position of the carbons. It requires mirrors and searchlight arrangements to give direction, and even screens have to be used to prevent the arcs from diffusing the light in undesired directions. In a continuous current carbon arc the positive carbon grows very much hotter at its extremity than does the negative carbon and, in the

open air, it is worn away by combustion and other causes. During this process the extremity becomes hollowed out, forming a little crater. The negative carbon, while this is going on, gradually assumes a pointed shape at its tip and also wears away, though far more slowly than the positive carbon. In this form of arc by far the largest portion of light comes from the highly incandescent crater of the positive carbon. As long as the carbons, if pure, are maintained at the proper distance apart the arc continues steady and silent. When the arcs are long and the electrode is small, the positive electrode does not form a crater, but it acquires a rough end. If, however, the carbons are impure or wet, or the distance between them becomes too great, the true electric arc rapidly shifts about in a flickering fashion and often becomes extinguished. When this occurs the arc can be restored by bringing the carbons into momentary contact again. Many ingenious devices have been produced by various arc lamp inventors to care for such emergencies and to keep the carbons at the proper distance apart while they are being consumed. The alternating current arc is symmetrical, relatively to each electrode, and both carbons have almost the same appearance. When the arc is enclosed in a nearly air-tight glass globe, the rate at which the carbons are consumed is considerably lowered; in the case of the continuous current arc the cratering of the positive carbon and the pointing of the negative carbon also is greatly reduced.

J. B. L. Foucault, a Frenchman, in 1843, suggested the use of carbons formed of the hard graphitic carbon found as a deposit in the interior of gas retorts. This was followed in 1846 by the granting of a patent to W. Greener and W. E. Staite, both British inventors, for making such carbons, but no great demand for them was created until the invention of the Gramme dynamo in 1870. F. P. E. Carré, also a Frenchman, in 1876, made a high quality of arc lamp carbons from powdered coke, lampblack and molasses.

In the past twenty-five years a great deal of attention has been paid by experimenters and research workers to processes for manufacturing carbons and much progress has been made in the art. A few details may be given here.

In general, the modern method of making arc light carbons consists in the use of any refined form of finely divided carbon, such as graphite produced in the electric furnace, soot formed from the smoke of burning tar or paraffin, and molasses or gum with which to make it into a paste. This is squirted through dies by a hydraulic press in the form of rods which are then baked at a very high temperature in special ovens from which air is excluded. It is important, of course, to provide a means to keep these rods straight until they are hardened by the baking process. Cored carbons are made in the same manner except that a hole through their longitudinal center is filled with a softer form of carbon. Certain kinds of carbons are covered with a thin plating of copper on the outer surface. The purity of the materials, uniformity of structure and freedom from ash in burning determine the commercial value of carbons. Usually they are round in section, but certain forms of arc lamps used in the lighthouse service require a larger carbon whose cross-section is fluted or star-shaped. Generally the positive carbon is of larger diameter than the negative. A cored carbon for the positive and a solid carbon of smaller cross section for the negative is the usual equipment for the continuous current arc lamp. The carbons for flame arc lamps are especially prepared by impregnating them with metallic salts, such as those of calcium, sodium and magnesium. In this type of carbon, which is generally composite in structure, the outer layer is pure carbon, the next is formed of carbon mixed with the metallic salts, and the core is made of this same mixture, but in a softer form. A flux, to prevent the formation of a non-conducting ash, also is included in the mixture. The carbons are arranged to point downward so as to keep them free of the slag formed while burning. The salts are utilized in this carbon to produce a yellow glow instead of the blue-white light of pure carbon. The quantity of light emitted from the arc also is increased. Flame arc lamps,

however, are suitable for outdoor use only, as objectionable gases are given off during their operation.

A large number of very interesting experiments have been made to determine the intrinsic brightness of the carbon arc crater itself. While the results achieved by numerous investigators vary considerably, it may be stated that Blondel, in 1893, after a series of careful determinations, announced his conclusion that the brightness of the arc crater was 160 candles per square millimeter. Also, in 1893, Violle made a number of tests which, together with certain assumptions as to the specific heat of carbon, led him to the assertion that the temperature of the arc crater was about 3,500 degrees Centigrade.

The arc produced by the alternating current offers an entirely new set of problems to the investigator. As the electromotive force reverses itself periodically, there are certain infinitesimal instants of time when no current is flowing through the arc. At these instants, the carbons continue to glow and the light is not extinguished. Provided the frequency of the alternating current is not too low, it is possible, therefore, to operate the arc without any visibly apparent break in the intensity of the light. Owing to the reversals of the electromotive force, each carbon in turn becomes the crater carbon and the illuminating power of the arc is distributed symmetrically or equally from each electrode and the hot gas near it.

The earliest attempts at outdoor arc lighting were undertaken long before the invention of the dynamo when the only available source of current was a battery of voltaic cells. Usually only one lamp was employed and a number of ingenious automatic regulating devices were produced to care for the consumption of the carbons and the variations in the current supply. From 1841 to 1844 Archereau and Deleuil operated arc lamps outdoors in Paris, one on the Conti dock and another in the Place de la Concorde. The too rapid consumption of the carbons was prevented by enclosing the arc in a glass globe from which the air had been partially exhausted. It was found, in spite of apparent success, that the cost of current from the voltaic cells was prohibitive and also that it lacked the steadiness requisite for commercial use. Although the public was greatly excited over these experiments they eventually were abandoned. A French scientist named Duboscq, in 1846, developed an arc lamp which was used in the opera, "The Prophet," at its production in Paris to represent the rising sun. In England a number of patents for improved forms of arc lamps were granted to De Moleyns in 1841; Wright in 1845; Staite in 1847, and others. Staite's work was especially noteworthy and his investigations were carried out with care and precision. He lighted a large public hall in England with arc lamps and later placed two of his electric lights on a tower especially built for the purpose on the Liverpool docks. He kept on with his experiments until his death in 1852, after which nothing more seems to have been done with his lamps. His work deserves fuller attention than it has received.

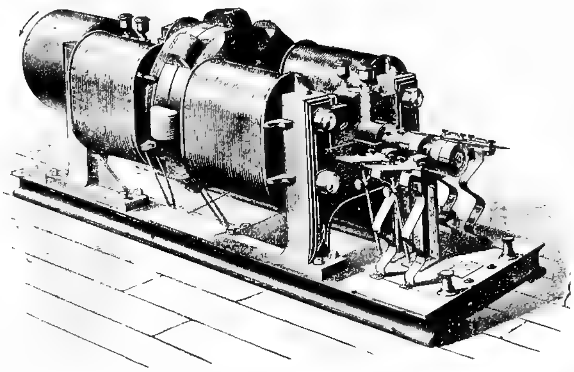
Two Frenchmen, Lacassagne and Thiers, invented in 1855 a regulating device which permitted the operation of more than one lamp on the circuit. What they really invented was a beautiful application of the differential principle, and it was the first time it appeared in the art, i. e., the series-wound magnet in opposition to the short-wound magnet around the arc, for controlling the feed of the electrodes. It laid the foundation for the operation of lamps in series in the same circuit, but their lamps had to be started by hand, after which they proceeded to burn with the carbons regulated. This marked an important step in advance in the art of arc lighting. Their invention was put to practical use in 1857 when they lighted a street in Lyons with two arcs operated with their devices. As in all previous attempts, these experiments had to be abandoned because of the cost of current from voltaic cells.

The so-called "Alliance" machine, which was the most satisfactory of all the early dynamos, was invented about five years later by Nollet and considerably improved by Van Malderen. This dynamo had been sufficiently developed by 1863

to warrant its use in a lighthouse at Havre, France, for maintaining an arc light. In 1866 a similar machine was used to light the yacht of Prince Napoleon.

The year 1870 is a most important date in the progress of arc lighting. It was then that Gramme produced his now famous dynamo which was a greatly improved form of that previously invented by the Italian, Pacinotti. Here was provided the first commercially successful substitute for the voltaic cells with which so many experimenters had endeavored to achieve practical results. While improvements were being made in the Gramme dynamo, a Russian named Jablochkoff was working on a form of arc lamp which became known as the "Jablochkoff candle," consisting of two parallel carbon rods separated by a thin layer of mineral insulating material, such as plaster of paris. At first the carbons were made about five inches long and about one-eighth of an inch in diameter. The tips of these carbons were pointed, and a piece of lead laid across the top to form an electrical connection, was held in place by a piece of asbestos paper. When the current was turned on, the lead was immediately fused, forming the arc. The candles were, however, for practical purposes tipped by dipping them into carbonaceous paste which was conducting, and an improvement upon the lead and asbestos arrangement. Later candles were made with carbons about nine inches long and three-sixteenths of an inch thick, which would burn nearly three hours. The first candles were used with continuous current, and it was found necessary to make one of the carbons twice as large as the other. In practice, however, it was found impossible to so regulate these carbons that they would burn exactly alike. Jablochkoff therefore experimented with alternating current, and was immediately successful in overcoming this defect. As thus modified, a current of eight or nine amperes was used, with a difference of potential between the carbons of from forty to forty-three volts. The Jablochkoff invention ranks with that of Gramme as one of the basic factors in the rapid development of the art of electric lighting in the last quarter of the Nineteenth Century.

It had many advantages over any of the arc lamps which had preceded it, such as those of Serrin and Duboscq, which were cumbrous in design, needed constant watching and required a separate source of current for each lamp. The simplicity of the Jablochkoff candle and its mechanism, the absence of need for a regulating device, and the possibility of feeding a



The Brush Dynamo-Electric Machine. Capacity—40 Lights of 2000 C. P.

number of arc lamps in series, gave to this invention the character of a very decided advance. As first exploited commercially it had some disadvantageous features. One of these was that if the arc was extinguished it could only be restarted by short-circuiting the carbons by a small piece of carbon or lead, a feature which became especially annoying when several candles were being operated in series. Another marked disadvantage was the short life of the candles so that several had to be installed in each lamp for all-night service, and it was necessary to switch the current from one candle to another by means of a communicating switch operated by hand.

These disadvantages were to a great extent overcome by an improvement made by Wilde, who eliminated the insulating material between the carbons and supported them so that when the current was off the ends were in contact. When the current was established, a magnet separated the ends, thus striking an arc. He

also used longer carbons, which added to their life. The elimination of the mineral insulation between the carbons also did away with the peculiar color of the light which had previously characterized the Jablochkoff lamp, and substituted clearer and whiter rays. But the Wilde modification had no considerable application in practice.

Other modifications intended to more effectively adapt the arc lamp to popular use followed, and devices of various kinds were invented, but most of them added materially to the weight and bulkiness of the lamp. Many of these devices became obsolete after the differential principle was introduced into the mechanism of the arc lamp.

The differential principle was not entirely a new feature in lamp design. Lacassagne and Thiers had included it in specifications of a lamp which they had patented as far back at 1855. But that lamp had never materialized as a commercial achievement nor attracted the attention of inventors to any great extent.

Lontin, in France, introduced the method of regulating the arc by a shunt circuit, connected differentially to a series of magnets or coils and thus made it possible for several lamps to be operated in one circuit from a single source of current. He applied this device to an improved Serrin lamp, and in 1878 lighted by a series of six or eight lamps, the Saint Lazare Station in Paris; so that he was probably the pioneer in the application of differential magnets in a commercial arc series. Soon after von Hefner Alteneck adapted it to the Siemens lamp, but the real success in the application of the differential idea did not come until Charles F. Brush, of Cleveland, Ohio, applied it to the system which he launched commercially in 1877.

In 1877, Mr. Brush lighted the Main Building (which has been kept over from the great Centennial Exposition of 1876 at Philadelphia) by Brush machines, each of which fed four separate arcs with a single lamp in each circuit; and subsequent to that he lit the Wanamaker stores at Market and Thirteenth Streets, Philadelphia, with the same arrangement of circuits. In the Fall of 1878 or beginning of 1879 these machines were replaced by Brush machines using lamps in series with differential control, which would thus appear to have become by that time an integral and established feature of the Brush system, which so rapidly became world-wide in its popularity and acceptance.

All of the early developments of the arc lamp, up to 1875, were the products of European investigators and inventors. The first arc lamp to be introduced in the United States was put out by William Wallace in 1875. This original arc lamp consisted of two flat plates of battery carbon mounted rigidly in a wooden frame. As the electrodes were consumed, a boy made the rounds and knocked each set of plates together with a hammer. A later development by Wallace mounted the upper electrodes in a holder attached to a rod. This holder was gripped by a clutch actuated by an electro-magnet in series with the arc. Mr. Wallace, before these American adventures in the field of arc lighting, had become notable in the electrical world as the first builder of generators in England, and he was the first manufacturer in America to apply the dynamo electrically to the process of electro-plating.

In connection with the development of generators Mr. Wallace became associated with Prof. Moses G. Farmer, of Boston, and the two evolved what became known as the Wallace-Farmer system of electric lighting, which embodied various mechanical improvements, an original type of generator, and an arc system which showed great improvement in the features of reliability, low maintenance cost, and a carbon life of about fifty hours, which was considerably the longest of any system then known. These features led to its adoption in many factories for purposes of illumination. But defects of various kinds developed in the system, one of the most pronounced of which was the flickering of the arc and the dancing shadows all around it. There was a lack of uniformity in the carbon plates, which flared up most unpleasantly and threw off sparks and soot, while some plates lasted much longer than others. An attempt to remedy these

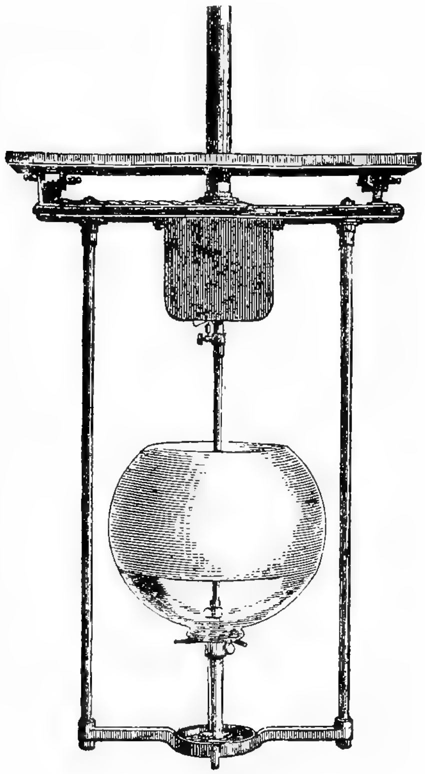
difficulties by replacing each of the carbon plates by twenty-four carbon rods proved impractical.

Charles J. Van Depoele, a Belgian, who came to America and is famous as the father of the "trolley" railroad system, which he developed in America, was also one of the early contributors to the development of arc lighting. He had experimented with electricity in Belgium, beginning in boyhood, and when he came to America he brought out the Van Depoele lighting system which included an individual lamp and generator. The system was installed in several of the Central and Central Western States. The generator of this system was so arranged as to automatically maintain the current constant and independent of the load. The constancy of the current was maintained partly by the magnetic leakage resulting from armature reaction, and variations of current too large to be relieved by that means were disposed of by shifting the brushes either by hand or by a regulator. Like most early types of open arcs this system operated at a low voltage and relatively high current (15 to 20 amperes), which produced a very white arc. But the light was often hidden by the electrodes and its brilliancy and effectiveness were greatly interfered with by the moving shadows and fluctuations they caused. The two 24-inch carbons had a life of sixteen hours.

With regard to the shifting of the brushes referred to above, by hand or regulator, this appears in reality to have been first done by Thomson and Houston in 1879, and the automatic regulating mechanism developed by them which kept the dynamo current of constant value from full load to no load, was in large measure the reason of the success and rapid expansion of the Thomson-Houston system of arc lighting. It removed at one stroke the necessity for keeping a full load of lamps on (by adding lamps in the station when others went out on the exterior circuits), saving energy and carbons alike, and both were expensive. The Brush and Weston stations at the time this regulation was introduced, always had a considerable number of arc lamps ready to throw on in order to load fully the circuits, *pari passu* as the number of lamps outside the station was reduced. Thus, in consequence of the Thomson-Houston regulator, all the lamps of the system were from the very first provided with shunting switches for cutting out the lamps, which would not appear to have been the case with any other system. The Thomson-Houston custom was, therefore, to encourage the shunting of the lamps by the switch, whenever it was desired to extinguish them. The exploitation of this system became commercial in 1879 in Philadelphia, and was carried on by the American Electric Company at New Britain, Conn., and subsequently by the Thomson-Houston Electric Company at Lynn, Mass., forerunner of the General Electric Company.

William Hochhausen, a New Yorker, developed a system which was introduced in 1883 by Henry Edmunds, an enterprising English capitalist who was largely interested in electrical development and who financed and introduced in England the Wallace-Farmer and Brush arc systems as well as the Swan incandescent lamp. The Hochhausen system was ingeniously designed to combine most of the desirable features in a single mechanism. The generator resembled that of Van Depoele, except that it was vertical instead of horizontal. Among its features was a small section of iron for the field flux, and a small auxiliary motor, which, by rotating the brushes, maintained constancy in the current. There were also minor improvements in the way the lamp carbons were fed together by gravity. The life of a pair of carbons in this system was eight hours, and as double carbon lamps were provided, they had a life of sixteen hours without attention. In those days this was a record of remarkable achievement, although it appears crude enough when it is compared with the life of from 150 to 250 hours of our present enclosed arc lamps. Like most of the others in that period, this Hochhausen system was of the high voltage, low current type, with all the defects of those systems, but later it joined in the general adoption of the low current (ten ampere) and fifty volt arc, which was a very important advance.

The types of arc lamps which have been discussed did not come into much popular use, and in this country were not commercially exploited to any serious extent, nor did arc lighting progress very rapidly anywhere until after the American pioneers in the arc lighting field had introduced their improvements. Mr. Charles F. Brush was the man whose activities first put the arc lamp on a commercial basis. He was the first American to apply to arc lighting the differential principle by means of which it was made possible to operate numerous



Early Single Brush Arc Lamp

lamps in series upon one constant-current circuit. The arc lamp upon which he secured patents in 1877 presented many improvements in mechanism, surpassing anything which had been previously produced. Besides applying the differential principle, this lamp discarded the rack and pinion, or "clockwork" feed, substituting therefor the brass rod and ring clutch which soon found general acceptance as a valuable and permanent feature of arc-lighting mechanism. This feature was at first derided, but proved so superior in simplicity of construction that it came into general use, and was the feature that survived while most of the other details of the mechanism were modified in later devices. Another very valuable innovation in the Brush arc lamp was the ingenious device for transferring the arc from one set of carbons to another in the double lamp.

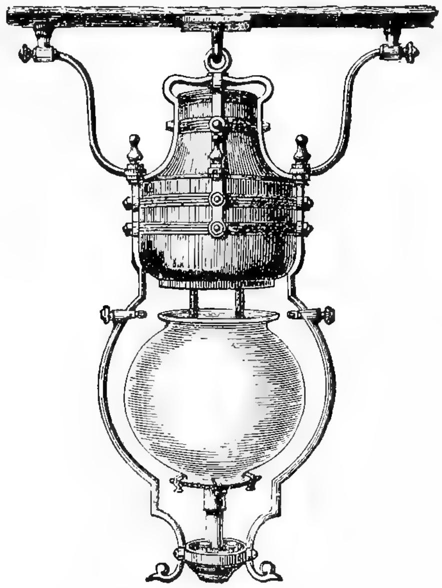
Mr. Brush was originator of the use of a thin layer of copper plate on the carbons, although his broad claims to the idea were affected by the fact that copper-plated carbons had been used by Wallace. It is probable that Mr. Brush determined more accurately or scientifically the amount of copper plating that was desirable. In Europe the carbons in the early days of arc lighting were much better in quality because there was always available a large supply of lamp black of excellent grade, and cheap labor to make this material into carbon. But American conditions made it impossible to produce such carbons at a rate cheap enough for their use in arc lighting, and it became necessary to make cheaper carbons, chiefly of coke. The carbons made of this material were not homogeneous and contained soft spots which were subject to "flaming" or rapid burning. Owing to high surface resistance of the carbons, contact with the carbon holder was uncertain, and lamp manufacturers tried various changes in the construction of the lamp to overcome this difficulty. Mr. Brush solved the problem by copper-plating the carbon instead of changing the design of the lamp. Moreover, the whole length of the carbon except the tip was plated for the purpose of reducing the loss or drop in the electrodes, so that the regulating value of the shunt magnet coil would be the same, or nearly so, at the completion of the run, when the electrodes were burnt out, as at the beginning. At the same time the carbons were prevented from burning as rapidly, and this was important when the carbons were so costly as in those early days. The Brush arc lamp developed rapidly as new and valuable discoveries

were made, and in a few years the Brush multipolar arc generator had also been perfected.

While the Brush system was being developed, Professors Elihu Thomson and Edwin J. Houston were making the experiments and designing generators, arc lamps and regulators which combined in one of the best systems of the period. The generator excelled in simplicity; the lamp was of the clutch-feed type. Their regulators were the originals of the brush moving type for constant current, being introduced as noted above, in 1879. The Thomson-Houston Company became one of the strongest electrical companies, and developed its electric light system to a place of much importance. These two companies, the Thomson-Houston Electric Company and the Brush Electric Light Company, proved formidable rivals to each other until the modern tendency toward consolidation brought them, and with them the Edison General Electric Company into one organization—the General Electric Company. This was a combination of much value to the progress of arc lighting because each of these companies owned patents that were valuable features of the better-developed system that came as its result.

It is interesting in this connection to note that when the old Brush Company was taken over by the Thomson-Houston Electric Company, the Brush system was still without an automatic regulator, although the dynamos themselves were in very extensive use. The manufacture of the Brush machines was transferred to Lynn, and the machines were then fitted with brush-moving and field-adjusting regulators of Thomson-Rice type. The Brush dynamo, especially in its later forms of the multi-circuit type, ranging up to no less than 150 arc lamps from one generator (the largest d.c. arc machines ever built) became when thus fitted with the regulator just mentioned, a most excellent embodiment of the qualities required for series arc lighting, and naturally a notable expansion of their use took place immediately.

The Weston arc lamp was the invention of Dr. Edward Weston, and with his other inventions in the incandescent lamp, was the chief basis of the United States Electric Lighting Company, one of the most important factors in its day in the industry, with many local lighting systems to its credit. The Weston lamp through all its successive stages of evolution and improvement remained notable for its simplicity and compactness of design. The generating Weston machine for arc service was also of conspicuous merit. It was one of the first to embody the feature of laminated pole pieces. The Weston system was broadly based on the use of 20-ampere current and low voltage, as distinguished from what were known as "open arc," high voltage systems.

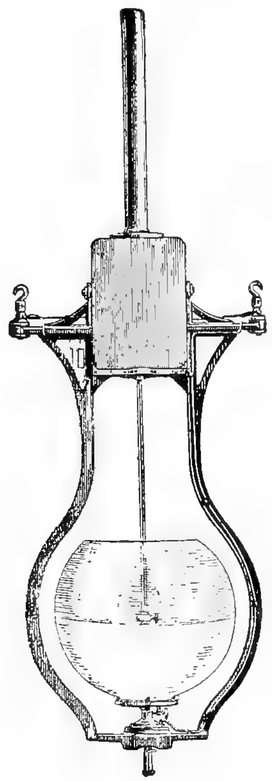


Early Brush Double Arc Lamp

The Weston and Waterhouse systems were taken over by the Westinghouse Electric and Manufacturing Company, and the good features of each were combined in the Westinghouse system, which was widely commercialized. It received quite an impetus in popularity through its adoption for lighting at the World's Columbian Exposition at Chicago in 1892-1893.

William Stanley devised a series alter-

nating arc lighting system in which special alternating current generators were used to furnish constant current. These generators regulated for practically constant current by means of high armature reaction and reactance. In its earlier work, flat carbons, similar to those which were used with the Wallace lamp, were utilized in the Stanley system in order to obtain long carbon life. Later these were abandoned in favor of ordinary round pencil carbons. This alternating current system was used for several years, but gradually died out as the result of basic objections to the open alternating current lamp and to other features.



Early Thomson-Houston Arc Lamp

About this time the Westinghouse Company brought out a direct current, constant current arc machine which in many features resembled the Stanley alternating current generator. It had a multipolar field similar to that commonly used in the alternating current generators of that period, and a toothed armature similar to the armature which was the then usual practice in alternating current generators. An 8-tooth armature was used in a 6-pole field and was connected to two special commutators in such a way as to obtain slightly pulsating direct current. Regulation was obtained entirely by excessive armature reaction, the field being separately excited. No regulators of any sort were provided. This system was pushed actively for several years, but like many others it went into the discard when arc lighting from the alternating current constant potential system began to come into general use. The Stanley type and the Westinghouse type of arc lighting machines were the only two which regulated for constant current without the use of any regulatory devices.

THE ENCLOSED ARC

The great drawback in all these systems was the short life of the carbons. About eight hours per set was an average life for a carbon at that time. Engineers and manufacturers were at a loss to account for this rapid consumption. It came to be a settled theory that this short life of carbons was a necessary condition which must be accepted or else overcome by using longer carbons. This short life is now known to have been due to the rapid oxidation of the hot carbons by the currents of air which continuously passed over the arc.

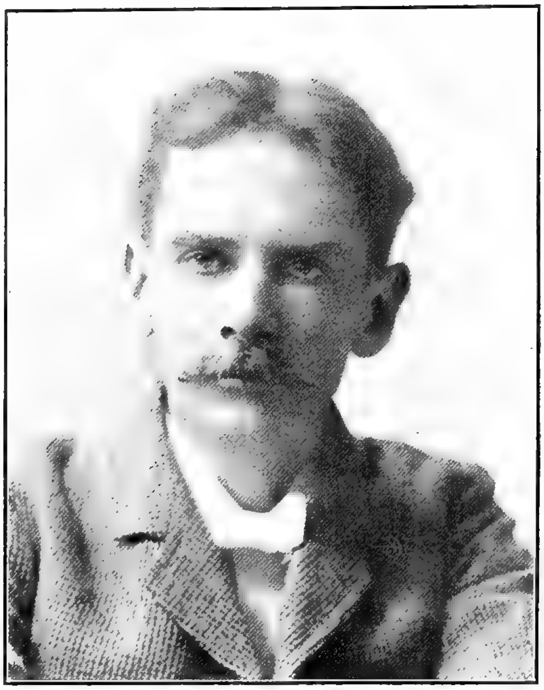
Developments in incandescent lighting became so rapid and effectual that it began to displace the arc in many places. As an illuminant on constant potential current it had proved its desirability to such a degree that many of those interested in the production of incandescent lighting looked for it to dethrone the arc and eliminate it entirely as a factor in practical electrical illumination. But the competition of the two systems compelled the producers of arc lighting apparatus to improve the designs of their lamps, reduce operating costs, and raise the standards of illumination and service. In the striving after improvement, experimentation was made

as to the effect of exclusion of the air from the light-giving element, and in this way the enclosed carbon lamp was evolved, meeting the situation very effectively.

So many investigators were simultaneously at work on this problem that it is difficult to select from among them the individual experimenter entitled to the prime distinction of opening up the second era of arc lighting, the beginning of which came approximately in 1893.

About this time, Louis B. Marks and some other inventors found that by placing a tightly fitting globe around the arc, and causing the upper carbon to pass into the globe in such a manner that only a very limited amount of air could enter it and reach the arc, it was possible to multiply the life of a trim of carbons by ten or twelve times. Though by this process the amount of light given out was somewhat decreased, the cost of trimming lamps and renewing carbons was reduced to at least one-tenth of the former price, and efficiency of the lamp was not reduced more than 50 per cent. The open arc could not permanently compete under this cost handicap, and while it held its own for a time where it was already installed, it was recognized as a superseded service, and new installations became almost exclusively of the enclosed lamp type. It would seem proper to call attention to the fact that candlepower tests showed that the alternating current enclosed arc lamp was practically no more efficient in light production than the contemporaneous incandescent carbon filament lamps, its only or real advantage being that it was an arc lamp, and that it had the superior color of light characteristic of arc lamps.

Many inventors worked on the problem of lamp improvement, and in five years from 1893 the Wood, Thomson, Adams-Bagnall, Manhattan and Westinghouse enclosed carbon arc lamps appeared. Carbon manufacturers were for a time very pessimistic as to the future of their industry, which they felt was doomed to almost complete extinction. But the result was entirely the reverse of their forebodings. Because of reliability of service and its reduced cost the number of arc lamps in use greatly increased. The introduction of the enclosed arc reacted on the quality of carbons most favorably, and another progressive factor which followed the improvement of carbons was the general adoption of a mechanism in which the clutching device acted directly on the electrode instead of on a steel rod, which had the effect of simplifying and greatly shortening the lamp mechanism.



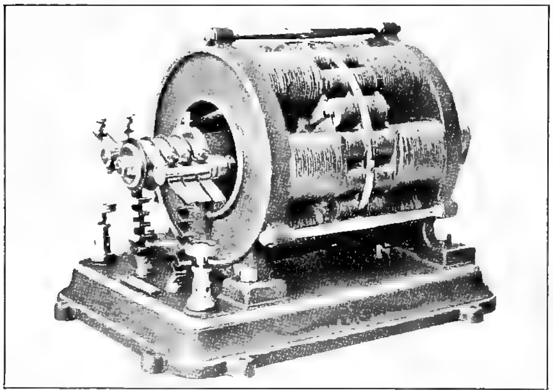
WILLIAM STANLEY

The change in the basic principles of arc lamp construction as they had been applied to the open arc, necessarily brought revolutionary changes of design in the various parts, and the question of size, shape and distance from the arc was carefully studied so as to make the globe as efficient and durable as possible.

The Wood and Thomson lamps designed during this period were taken over by the General Electric Company. The Westinghouse Electric and Manufacturing Company took over the works of the Manhattan Construction Company, developing that plant into its present Newark Works, which is the lamp factory of the Westinghouse Company.

The total exclusion of air from the arc was found to make the arc unstable and to deteriorate the electrodes by making their ends smooth, hard and of very high resistance. Accordingly means were devised for admitting small quantities of air through spiral passages or similar devices, of which there were many.

While these discoveries as to the quality and phenomena of the arc-light were being made and applied, other and important investigations were being made into the alternating current generating and distributing system. This had become firmly established, and an attempt to use it again for arc lamp operation led to the invention of



Multipolar "Wood" Arc Dynamo, 1879

the constant current transformer and the "regulating reactance," the value of which brought a revolution in arc lighting methods. The constant-current arc generators were soon superseded by the new alternating current method and apparatus.

The regulating reactance consisted chiefly of a coil in series with the arc circuit and a laminated iron core within the coil, provision being made to change automatically the relation of coil and core, thus varying the reactance of its coil. The coil was ordinarily moved, and the core held stationary, this movement being arranged so that the varying inductance of the coil tended to maintain the current in the arc circuit constant. The regulating reactance when operated in connection with the alternating current enclosed carbon lamp presented a great stride forward in the work of arc lighting.

The principle of the constant current transformer first appeared in the celebrated repulsion experiments of Elihu Thomson, being foreshadowed by the beautiful demonstration of the lighted lamp floating under water without exterior connections of any kind. The first step made in an apparatus producing a constant alternating current by transformer action appears in two patents of 1889, which show such a transformer, the secondary of which delivers constant current without any moving parts. The amount of material and the size of the apparatus were both larger than was desirable, and this led to the production and application of the moving coil constant current transformer based on the principle of repulsion noted above. The application for a patent on this was made in 1891, the fundamental "tub" transformer. At the same time it was realised that variable reactance might be employed and a patent filed at the same time shows an effective constant current variable reactance regulator.

The regulating transformer as usually constructed consisted of two coils, one stationary and one movable, the movable coil being counterbalanced and adjusted so as to approach and recede from the fixed coil with a minimum of friction. The primary coil was usually stationary, while the secondary was repelled from the primary in proportion to the current passing through the secondary. As the secondary coil was repelled, the magnetic flux through the secondary decreased, and the induced current and voltage were correspondingly decreased.

One of the main factors in the success of the arc lighting system with extensive circuits was its immunity from damages by lightning, and this was largely due to the introduction of the blow-out lightning arrester of the old Thomson-Houston Company.

The story of the development of the arc light up to this point would not be complete without reference to the fact that in the later years the gradual disappearance of arc light dynamos—except in isolated plant work—or of dynamos con-

structed especially for circuits of arc lights, was due to the universal introduction of the practice of generating current by large alternating current generators, operated at the great modern steam stations or by waterpower, the energy from which when "manipulated" could be used eventually to run from the common source of supply all kinds of electric load, including arc lamps, incandescent lamps, motors, etc., *ad infinitum.*

THE LUMINOUS ARC

As far back as the early part of the last century, attempts were made to use a metal as an electrode, or to add some substance to the carbon itself, which would increase the light-giving value or efficiency of the arc for purposes of illumination. Such work was seriously resumed at the beginning of this century, and has developed some very important results; so that there are now at least three main types of arcs that with greater or less success in the commercial field embody a marked advance over the old plain carbon arcs. Thus there are electrodes yielding the so-called "flame arcs," based on an admixture of other substances with the carbon; there are arcs based on employing an oxide for one of the electrodes, of which the magnetite lamp is literally the shining example, and there are arcs of the mercury vapor type, although the latter burn in a vacuum and do not "burn away" the electrodes, thus being akin to incandescent lamps.

A great many inventors have directed their attention to the magnetite and kindred lamps, too numerous here to mention; but it may be noted that as far back as 1902, to take one great leader, Dr. C. P. Steinmetz experimented on a magnetite electrode. It does not appear that the lamp was at first a notable success, but that early results indicated that the magnetite electrode was not efficient enough to warrant following up that line of development. But Dr. Steinmetz, believing it was a real "lead," had arranged for the building of fifty lamps, and these were permitted to go through the shops at Schenectady.

Mr. C. A. B. Halvorson's memorable work on the lamp began in 1902, and the magnetite lamp in practically its present form was exhibited on the streets of Schenectady in the spring of 1903. An interesting and authentic account of his work and other work incidental thereto was given in December, 1911, by Mr. Halvorson in the *General Electric Review,* dealing with the theory and operation of the magnetite arc and lamp mechanism very fully, including the design of both the up and the down draft lamps and the design of the justly famous "Ornamental Luminous Arc Lamp."

It should be noted in passing that R. Fleming was responsible for the construction of the electrode which carries the metallic salts, or, in other words, invented the iron shell filled with the powdered oxides, which form persists to this day. In such lamps there was or is a consumable electrode composed of the oxides of iron, titanium and chromium, while the other electrode consisted of a copper block and was classed as non-consumable. These electrodes had a life which, measured by the average longevity of other electrodes then in use, was remarkably long. The reason is that the lower or negative electrode, which supplied the arc stream with its luminous matter, was a composition of oxides unaffected by the action of air, while the block of copper which served as the positive electrode was so large that radiation prevented its oxidation. The original claims for this electrode placed its life at 500 to 600 hours, but in commercial practice this was reduced to about sixty or seventy-five hours. Since then it has been vastly improved. The General Electric Company put this lamp into seeming commercial form, but various difficulties developed. One especially persistent was the fact that the electrodes would become coated with iron oxide in a fine red powder which proved an insulating material inimical to the quality of the light. Other troubles came from the melting of the electrode material, hot particles of which would fall on the globe and break it. Windstorms would cause a down-draft in the chimney so that the fumes of the electrode would lodge their fine dust ("soot") on the globe. Hence, the illumination

given out would be less than that of the enclosed carbon arc.

Soon after this appeared, the Westinghouse Electric Company put forward a lamp which also had an electrode com-

posed of the oxides of iron, titanium and chromium, but was radically different in construction from the other lamp. In this, known as the "metallic flame lamp," the negative or oxide electrode which it was necessary to make long, was placed uppermost. Below it was the small, positive electrode, a double spiral, wound from copper and steel ribbons. A feature of this lamp was the "down-draft." Before that the uniform arc-lamp practice had been to so construct the lamp that the air heated by the arc passed directly upward out of the lamp. This served every purpose for the carbon lamps, and was well

within tolerance in the magnetite lamp. It was true that in the latter the ascending gases caused rapid accumulations of soot upon the cooler upper electrode; but by causing the heated gases in their upward passage to draw new air downward around the arc a large part of the difficulties arising from accumulation of soot and slag had been overcome.

The development of these types of lamps by both the General Electric and Westinghouse Electric Companies was very rapid. The soot-forming trouble was brought down, and the light-giving capacity of the lamps was greatly improved by modifications and adaptations in the mechanical structure of the lamps. The electrodes used in these lamps have a life of about two hundred and fifty hours, while the energy consumption is about 0.4 per candle.

As is said by Professor C. D. Child in his "Electric Arc.": "The most important of the arcs between oxides is the magnetite. In this the cathode is magnetite ($Fe_3 O_4$) and the anode is copper. Magnetite is used for the cathode because it gives off a vapor which is very luminous when in the arc, and copper is used for the anode because it is not rapidly burnt away, and does not need to be renewed as often as a carbon anode. The anode is large and rapid conduction of heat by the copper keeps it at a comparatively low temperature. This arc is very efficient and the electrodes need little attention because of their slow consumption." In the modern lamps of this type the life of the positive electrode is anywhere from 2,500 to 18,000 or 20,000 hours, depending, of course, upon the current rating of the lamp. The life of the negative electrodes in practice varies between 125 and 350 hours, depending, of course, upon the amplitude of the current flowing. It is interesting to note that at least 250,000 up-draft magnetite lamps were already in service more than 2 years ago, whereas probably at that time not more than 10,000 down-draft magnetites were in use.

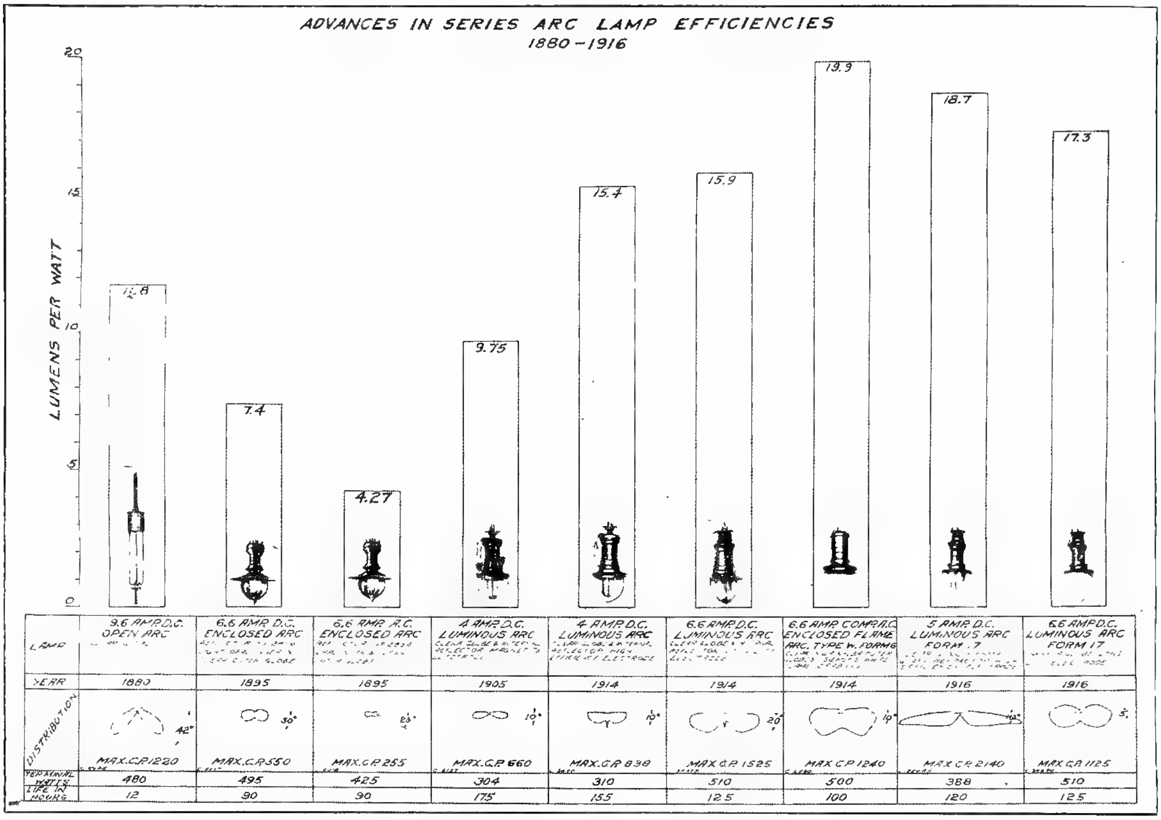
The titanium carbide lamp was also a development of this period. This lamp, on account of its high efficiency and the fact that it could be operated on alternating currents, made it a much discussed factor in street lighting matters over a term of several years. It was, so to speak, a menace to the magnetite lamp, and thus undoubtedly hindered the commercial development of the latter system. Several hundred titanium lamps were operated over a long period, and it is interesting to note that the "down-draft" feature was applied originally by Halvorson, more particularly for use in them. This was because of the lighter and less voluminous deposit of titanium carbide which was hence easier to control. The heavy dark-red deposit of the magnetite lamp was not easily cared for by the down draft, and thus the General Electric Company developed the up-draft lamp for use with this particular electrode.

THE FLAME ARC

And now as to another kindred development due to Hugo Bremer, who experimented in the addition of an impregnating salt to the carbon electrodes to increase the brilliancy of the light. The Bremer flaming arc lamp, commercially introduced in 1898, marked a notable increase of efficiency which came not only from the chemical impregnation of the electrodes, but also in their arrangement at an angle of about 30 degrees inclined downward through guide tubes. The feeding and separation of the carbons was controlled by a magnetically operated clutch mechanism similar in principle to the clutch which had been in use, with the enclosed carbon arcs. The lamp of Bremer was of a semi-enclosed type, the arc being maintained within a globe communicating with a condensing chamber to collect the soft white powder ("soot") formed by the boiling away of the mineral contents of the carbons. The enclosure of the lamp was not sufficient to give a carbon life of more than from 12 to 18 hours. The carbons used were of small diameter and varied from 18 to 30 inches in length. The condensing chamber was an important feature, although as at first designed it was not sufficient to prevent the rapid covering of the globe with a deposit that made it necessary to clean the glass every time a

new trim of carbons was put in, in order to secure a proper degree of transparency for effective lighting.

There were two general types of Bremer carbons—the cored and the homogeneous, depending upon operating conditions. In the cored carbon the outer shell was composed of the ordinary hard carbon. The core was a softer substance, usually a mixture of calcium oxide and carbon, but often with an addition of



The Increase in Arc Lamp Efficiencies

ous, while the vapor stream gave out an intense, reddish-yellow light. The arc was longer than the old one and had the appearance of a flame, whence came its name of "flaming arc."

Professor A. Blondel, whose work followed that of Bremer, evolved a lamp in which the carbons, arranged vertically, were of unique formation. They were relatively large in diameter, consisting of several concentric, annular shells, alter-

fluorides or other materials. The homogeneous carbons were composed of a thoroughly blended and carefully baked composition of carbon and mineral materials, making a hard and solid mass. When operated in a lamp, the carbon forming the conductor was volatilized and the light producing materials were volatilized into the arc. It was not, like the original Davy arc, composed of a bluish, non-lumin- vapor between two intensively incandescent carbon points. In the Bremer arc the electrodes were comparatively non-lumin-

nate layers of hard carbon and mineral material, respectively. These carbons were from 12 to 14 inches long, and their vertical arrangement made it possible to use a carbon-clutch little differing from that used in the ordinary enclosed carbon lamp.

Many inventors began to busy themselves with evolving new forms of the flame carbon lamp. All except Blondel used the inclined V arrangement of the carbons. These forms were developed in Europe, and a few of them were intro-

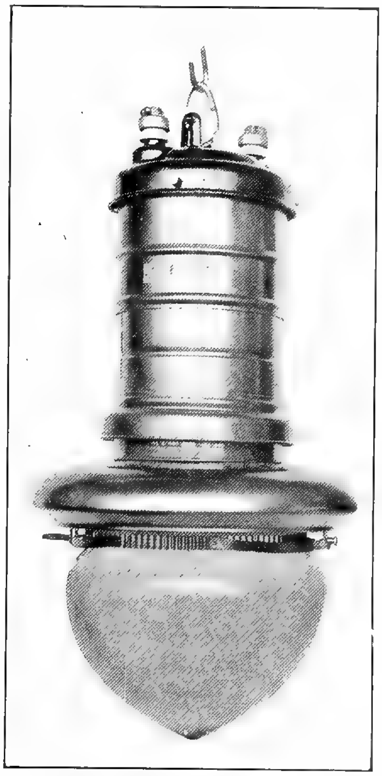
duced into this country. A difficult problem in connection with these lamps with the V carbon feed was the construction of the focussing mechanism required to feed both carbons at a uniform rate. These mechanisms were varied, many of them ingenious and some quite complicated. Some reverted to the gravity operated, clock-fed mechanism of an earlier day, and one was actuated by a small motor in the top of the lamp. Because of the cost of its maintenance this type of lamp found little vogue in this country. It has been said recently: "As a matter of fact the flame arc is now as extinct as the 'Dodo,' except for its use in searchlight work. The etching of the inner globes on the enclosed flame arcs was one of the most serious difficulties experienced, and had nothing to do directly with the heat, the etching being a chemical phenomena."

One of the serious troubles with nearly all of the lamps of the flame carbon series came from the fact that the non-conducting oxides added to the carbons to increase their luminosity would become fused as the result of their combustion, and in that condition they ran down the sides of the carbons, forming glassy, insulating beads which prevented the carbons from coming into contact when the lamp was extinguished and from restarting without attention.

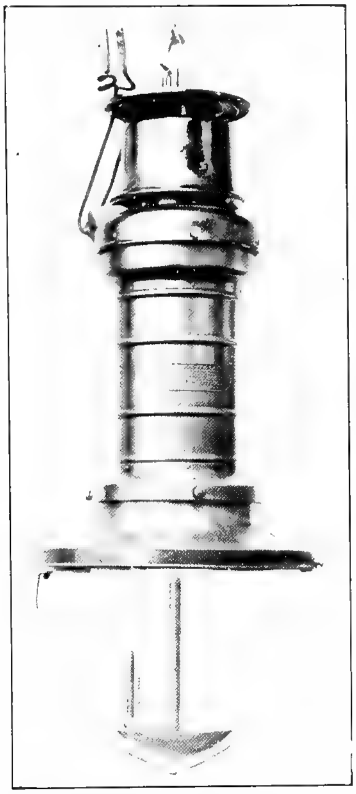
Another trouble was how to dispose of the volatilized mineral matter. Sometimes it was allowed to escape freely, carrying with it a mephitic odor and choking fumes, never to be forgotten—or forgiven. If the attempt was made to hold it in the lamp it settled on the globe, reducing the luminous efficiency of the lamp more than fifty per cent. The road to the solution of this difficulty was found in the provision of a cool metal chamber through which the gases were passed before escaping to the outside air. This reduced the trouble to a considerable degree and was the forerunner of what was called the "Regenerative" lamp. It was based on the theory that if the space above the arc should be connected with the space below the arc by a metal passage, a part of the soot would be condensed by the tubes, and the gases would be used again and again. This lamp was introduced to the American market by the Adams-Bagnall Company. The idea was that under the conditions named the globe would stay clean, but this was not wholly accomplished in active practice.

THE ENCLOSED FLAME ARC LAMP

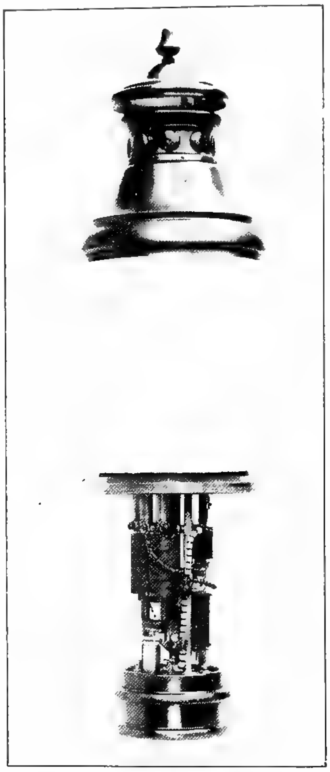
The next step was the enclosed flame arc lamp, now the most efficient and economical lamp in service. Like all the preceding types of arc lamps this one, in its later developments, is the result of the combined efforts of many workers, but it is probable that Tito L. Carbone, of France, is the inventor whose work has been most valuable in this evolution. He found by experiment that the "soot" of the flame arc lamp, when present in large quantities, would deposit on the surface with which it first comes into contact, but that when the amount of soot in the circu-



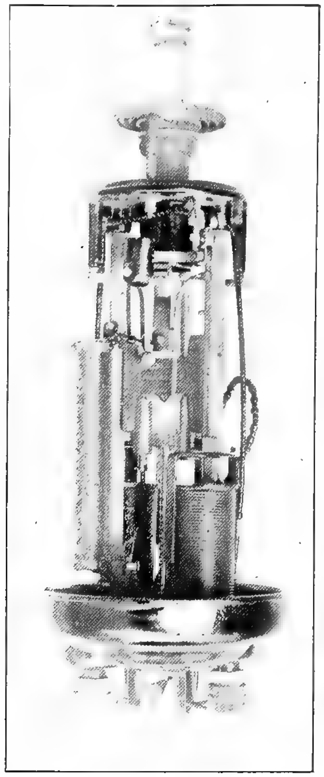
Enclosed Flame Arc Lamp



Type of Direct Current Luminous Arc Lamp



Mechanism of Direct Current Luminous Arc Lamp



Mechanism Enclosed Alternaing Current Arc Lamp

lating gases had been reduced by allowing a portion to deposit out, the remainder would not readily condense on a hot surface. In harmony with these principles, Carbone provided the flame carbon lamp with a flat, disc-shaped metal chamber, so placed upon the arc that the heated gases, rising upward, pass into the condensing chamber. He then provided a globe for the arc so shaped that the portion adjacent to the arc, through which the useful light passes, was kept very warm, while the lower portion of the globe became somewhat cool.

Various improvements have been made in the Carbone lamp. One valuable improvement is that the globe around the arc is maintained at proper temperature by surrounding it with an outer globe to shield it from air currents, an expedient which has greatly reduced the deposit of soot on the inner globe, gave a much higher light efficiency and brought an increase in the carbon life which now, in many cases, exceeds 125 hours per trim. The focussing mechanism is efficient in operation, insuring that the arc will always be so located that the useful light can pass out through the soot-free portion of the inner globe.

In the evolution of the arc lamp many changes have occurred, so that there is little resemblance between the open arc, flickering, sputtering lamp of forty years ago and the luminant, clear, efficient flame arc lamp of the present day. Many of the intervening inventions have been discarded, but others, such as the regulating magnets, chain-wheel support, the ring carbon clutch for holding and feeding the carbons, the economizer and other essential details are of proven efficiency and service in the modern types of arc lamp.

The industry has had to contend with innumerable problems and difficulties. It is one that depends for its success upon many other industries—the manufacturer of carbons, manufacturers of glass, porce-

lains, chemicals and alloys and many other branches of manufacture and engineering. It has reached a high plane, and some heights beyond, in connection with work for the war that cannot now be properly dealt with here, but will be referred to in regard to the American searchlight work done for war purposes (1917-19), of which interesting details are given in another section and chapter.

THE MERCURY ARC

All of these lamps need a lower voltage than the carbon arc, and all give a greater amount of light for the same energy. Some of the metallic salt combinations give trouble in lamp regulation, and others in starting the arc after it has been extinguished. The rectifying characteristics of any metallic flame arc make it impossible to operate it on alternating current at less than about five hundred volts, which means that its operation on a commercial scale is out of the question. The early metallic flame lamps, therefore, were operated on direct current generators, similar to those used with the old open-arc lamps. For a time it seemed that it would never be possible to apply the benefit of the constant current transformer to the highly efficient metallic flame lamp. But the solution of this problem came with the invention and development of the mercury rectifier, consequent upon the invention of the mercury arc lamp, which is, however, equally entitled to be included in the vacuum, incandescent lamp class of today.

The scientific journals of 1860 recorded the discovery by Way of the fact that if an electric circuit was opened by a mercury contact a long, brilliant green arc was produced. At that time such discoveries had little significance outside of the realm of pure science. Even when, about twenty-five years after Way's discovery the arc light began to enter the realm of the practical, no one seems to have thought that the green, mercury arc had anything to do with the problem. The arc light in its development seemed to get along very well without mercury, which was then an expensive metal, the production of which was virtually a Spanish monopoly. About thirty years after Way's announcement Dr. Peter Cooper Hewitt began experimenting with the mercury arc, but because of its quality of rapid oxidation he pursued the plan of trying to exclude the air and thus surmounted the chief obstacle to the development of the mercury arc. He was thus able to produce the Cooper Hewitt vapor lamp, the early form of which furnished a long, bright arc of high efficiency and great stability due to the passage of the electric current through the vapor of mercury volatilized in a vacuum.

This Cooper Hewitt mercury vapor lamp was brought into commercial use about 1901 in the form of a long glass tube about one inch in diameter with an electrode in each end. The lower end of the tube, which was usually made the cathode, contained a quantity of mercury. To start the lamp it was necessary to tilt it sufficiently to bridge the space between the electrodes when the mercury would be immediately vaporized and the arc established. The tilting was at first done by hand, but later various starting devices were developed, the final and most successful being an electro-magnetic arrangement to raise one end of the lamp.

This lamp was a device new in theory and unique in application and efficiency. Its monochromic, well-diffused light makes it excellent for continuous, accurate work. The lamp has a long life and requires little attention. The character of the light from the mercury arc is such that all shades of red appear black and other color values are distorted, and a peculiar appearance is given to objects which depend upon color for their distinguishing feature. Red rays are entirely missing from this light, but may be supplied by a light transformer or polarizing reflector behind the tube. Later units have been much more efficient than the original lamp, and by the introduction of the Heraus quartz tube, made by working transparent quartz in the oxyhydrogen flame, a lamp has been produced by which an arc is operated in higher temperature and pressure, producing a light much richer in red rays, with a notable reduction in the size of the lamp.

When a metallic vapor arc is established it will pass current in one direction, but it

is impossible to reverse the current except by the application of a high voltage, the value of which depends upon the metal used, the value being exceptionally high in the mercury arc. Dr. Hewitt in his intensive study of the possibilities and phenomena of the mercury arc decided that because of this characteristic of permitting current to pass in one direction only, it might be employed to rectify or convert alternating current into direct current. From his experiments in that direction was evolved the present mercury arc rectifier which was readily adopted for the production of a constant direct current for arc lighting circuits, in connection with the constant current transformer already mentioned. Thus the present metallic flame arc system was commercialized and completed.

PETER COOPER HEWITT

SEARCHLIGHT DEVELOPMENT

At a very early stage in the development of the arc light came its application to lighthouses, and the evolution of searchlights and focussing lamps, all predicated upon the use of the arc, although in some of the more recent forms resort has been made to the latest types of incandescent lamps with strikingly successful results. The recent Great War made a most emphatic demand for improvements and perfections in military and naval searchlights, and this work will be taken up in some little detail in the chapter of the use and service of electricity in the war after the entry of the United States in 1917. There have been several lines of development, the chief among them being the big searchlights, fixed or movable, and the other the elaborate and complex Fresnel lens lanterns employed in the splendid lighthouses that mark nightly the American coast line. From these, whose rays

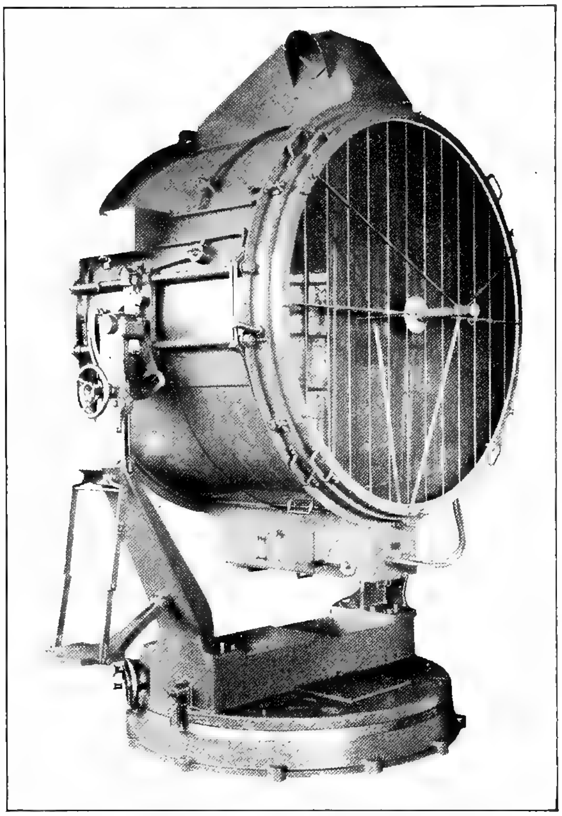
"Lie like a shaft of light across the land
And like a lane of beams athwart the sea,"

we range downward through many groups of focussing lamps such as those used on steamships or locomotives, for the theatrical "spotlight" and those for the "movies."

As a matter of fact, the earliest arc dynamos ran a single arc lamp, and this was naturally often associated with a projector. The first arc dynamos of the Gramme type were thus designed for such use, and it is believed that probably the first drum armature in the U. S. A. was the Siemens dynamo imported by the Navy and installed at the Newport (R. I.) Torpedo Station to operate an arc light for projection. The early searchlights for naval use were, of course, of relatively very minor capacity. Outside the arc mechanism, sometimes worked by hand, the main item was the reflector. A notable advance was scored by Col. Mangin, in France, in his concave-convex reflector, silvered on the back or convex surface, the surfaces being spherical. The light is reflected on entering and again after reflection, which so bends the rays as to cause them to emerge in a nearly parallel beam. But as the diameter of the lens is increased, this type becomes impracticable, not only because of the great weight due to the thickness of the glass at the edge, but on account of the risk of cracking the mirror by unequal heating, the thick edge absorbing much heat and diminishing the light by its absorption. The larger lenses are therefore, if of glass, made as thin as permissible and worked by grinding and polishing machines to the parabolic form. On the other hand, owing to the vital importance of true optical surfaces in the mirror, the processes of spinning, pressing or casting them from metal do not respond to the exacting necessities of large searchlight mirrors. With regard to these conditions and the development associated with methods for meeting them, Professor Elihu Thomson in an interesting review of the subject, says:

"It is very important in searchlight work of high type that the mirror shall have a consistent curve, by which is meant that it shall at no part of its surface depart perceptibly from what the optical conditions require. When it is remembered that the light source at the focus is only a moderate distance, a few inches, from the mirror, while the reach of the light beam projected may be miles away, it is readily seen that we are, as it were, working on a very short arm of an extremely long lever, regarding the mirror surface as the fulcrum. The relation of distance from focus to mirror and from mirror to distant object may be say 1 to 5,000 or more. It follows from this that in such cases, if the light source be one-half inch in diameter only, the least possible spread of the rays with perfect accuracy of mirror surface will be not less than 200 feet. It follows also that any rays which are inaccurately reflected will either diverge from the main path, or converge, cross, and then diverge, a small error in the optical character of the surface leading to a highly magnified error at the distant point. Emphasis is here laid upon these conditions of accuracy to show why it is that the processes of spinning, pressing, or casting of metal mirrors, often proposed, must be neglected in the production of large searchlight mirrors. However, consider-

able results of promise are obtained by methods which were practiced on a small scale by the writer several years ago and independently by Sherard Cowper Cowles in England. By the use of a glass mould or matrix, which by optical methods of



The Searchlight as Late Developments Have Made It—Sperry Type

grinding, polishing, and figuring has been given the correct form, we may chemically deposit on it a film of silver from a solution. All mirrors are now so made, where formerly they were coated on the back with tin amalgam. This silver coating, very thin at best, is next reinforced by the deposition of more silver from an electrolytic bath. This is again followed by a heavy copper layer, or other strong metal coating. We now have what is virtually a metallic mirror with a glass front. Methods are now applied to remove this glass front or matrix, so as to use it for forming other like mirrors.

"The copper-silver deposited mirror is, of course, thin and flexible, and must be given a rigid backing and framing so that it will permit of being mounted and used instead of the glass mirror. It is, of course, much less fragile and far less costly in time and labor to produce. Moreover, it will bear much more intense radiation, as it cannot crack as glass will do if subjected to too intense radiation. The silver surface is automatically obtained in the highest degree of polish and accuracy. It can be coated with a thin flowing of proper lacquer to prevent corrosion by the sulphur gases in the atmosphere. The progress recently made in lightening the equipment and increasing the facility with which it can be transported and handled will in itself form a most interesting chapter in the development of the modern high-duty searchlight apparatus."

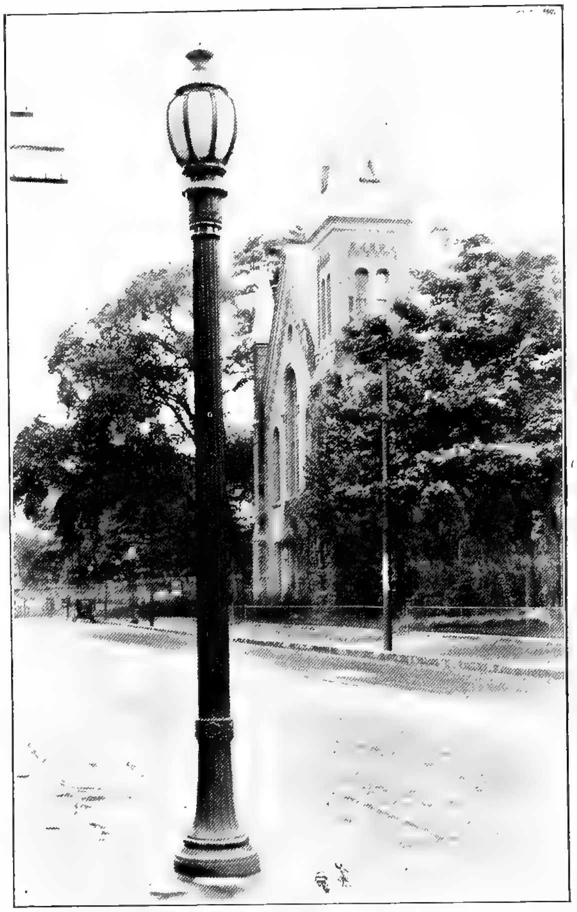
THE EVOLUTION OF ELECTRIC STREET LIGHTING

Up to the time of the introduction of gas, street lighting the world over was done solely on a severely individualistic plan with torches of resinous wood carried in the hand or placed in a fixture or in a cresset swung by pole over the shoulder. The alternative to this plan was the use of shallow lamps, even shells, holding animal fat or oil, in which the wick was immersed. The natives of Sumatra are said to have carried captive fire flies for the illumination of trails through the tropical forest. Next came tallow, wax and stearine candles, either placed in windows or street niches or protected in portable lanterns. Six hundred years ago there were just three fixed public lights in Paris, from which may have come first its designation as La Ville Lumière. Two hundred and fifty years later, five hundred streets in Paris were lighted by some 1,500 falot lanterns, dependent like isolated plants on the energies of individual citizens, for which reason like so many other later isolated plants, the plan was abandoned, and the apparatus junked. In 1662, civilization asserted itself in the resort to the adoption of a street lighting system furnished by a public utility corporation; and

in 1667 futher refinement was reached at the hands of La Reynie, who had the proud and unique distinction of being not only a police officer but the first illuminating engineer. Another century passed, and Chateau Blanc won a prize for street lighting with his reverberes, or reflectors, suspended 25 or 30 feet in the air, the lamps burning oil. No less than five-and-a-half leagues were "permanently" lit up in this way between Paris and Versailles, by 1777; and an observer of the times exclaimed: "No city, ancient or modern, has offered utility on such a scale." The lighting of London followed also such lines of advance; and as many as 15,000 street lamps are said to have been installed by 1738. Street lighting cressets were noted in Boston as early as 1695; and two years later, a very complete system was developed in little old New York, with a pole and lantern projecting over the thoroughfare from every seventh house, lighted up on a moonlight schedule. To this succeeded street lighting posts in 1762, with oil lamps; and for Boston ten years later, John Hancock's committee brought out some 400 street lamps from England, which seemed to have been far more acceptable than tea imported about the same time; and were doubtless kept trimmed with whale oil from the famous colonial fisheries that abounded in the waters of New England.

With the coming of gas and the adoption of modern utility methods, hitherto faintly adumbrated in water supply, canals and roads, the world left behind it, actually and literally, the Dark Ages. London got its first street gas lighting service in Pall Mall in 1807, with low posts and three globes on each, an exact anticipation of later White Way electric lighting systems seen in so many American cities. The first gas street lighting witnessed in America was at Baltimore in 1817, and with that began the new era, which after one hundred years, finds gas still highly appreciated as a house illuminant, but to a considerable extent, crowded from the service of outdoor lighting by the electric arc lamp, which in turn, as the era closes, finds its supremacy contested by the modern electric incandescent lamp of high candlepower and equally high efficiency and economy.

The story of the arc lamp as such has already been told in this chapter, and the production of electric current for exterior and interior lighting has also been dealt with in the chapter on the evolution of the dynamo. There was street lighting



Low Post Type of Arc Street Lamp

with the celebrated Jablochkoff "candle" as early as 1877, in Paris, for about half a mile in the vicinity of the Opera House, with an "effect incomparably finer than any show of artificial illumination ever before seen." Displayed also on the streets of London and New York, these "candles" soon dimmed their relatively ineffectual fires before the arc lamps of American invention and then faded from the

scene forever. The first public street lighting by arc lamps in America dates back to April, 1879, when Brush put in service twelve of his lamps on the Public Square in Cleveland, where his factory was located. Speaking of this memorable event and of one equally striking, Mr. S. E. Doane in a paper read before engineers in Cleveland in December, 1915, said:

Modern Method of Arc Lamp Trimming

"Early in 1914, the first Mazda C. (incandescent) lamp in actual service was installed in the same city of Cleveland which witnessed the first demonstration of the arc lamp. This is a curious coincidence, but it is certainly a remarkable whim of chance that the two illuminants, both epoch-making in the history of artificial illumination, should both have their first practical application in illuminating the same street crossing, Ontario and St. Clair Avenues. The arc lamp was first shown at the northwest corner, and the Mazda C. lamp 35 years later at the diagonally opposite corner."

Much of this early street arc lighting was done with clusters of lamps mounted on towers, where, like midnight suns, they were fondly supposed to rival both sun and moon in illuminating power. A few of these towers, which were carried up often to heights of 150 or 200 feet, still survive in some sections of the country, but they have no part in the modern art of street illumination, and may be compared to mammoths and mastodons. The whole tendency has been away from large units, or sky-high units, although in incandescent lamps the later counterpart of the primeval arcs has been seen in some of the monster bulbs of several thousand candlepower, strung aloft to illuminate large areas like ball grounds, racetracks, tennis courts or skating rinks.

Through all the period of, say, from 1877 to 1920, the arc lamp underwent, as already noted, many evolutions and improvements, all of which were largely influenced and determined by street lighting conditions and which owed their success to a series of great inventors, like Brush, Elihu Thomson, Fuller, Wood, Hochhausen, and Sperry, to mention only a few of the American leaders. The series arc lamp of Brush, with regulating shunt coil, and his double carbon "all-night" lamp led the way. The enclosed carbon arc lamp perfected about 1894, enjoyed an immense vogue, because of its long-burning capacity, and its diminution of the expensive process of frequent hand "trimming" with carbon sticks. The magnetite lamp came about 1904, in close competition with the long-burning flame arc around the same time, and with many and sundry variants of which the number grows down to the present moment. To all this splendid story might be applied pertinently and even pathetically, the fine stanza of Tennyson:

"Our little systems have their day;
They have their day and cease to be.
They are but broken lights of Thee
And Thou, O Lord, art more than they."

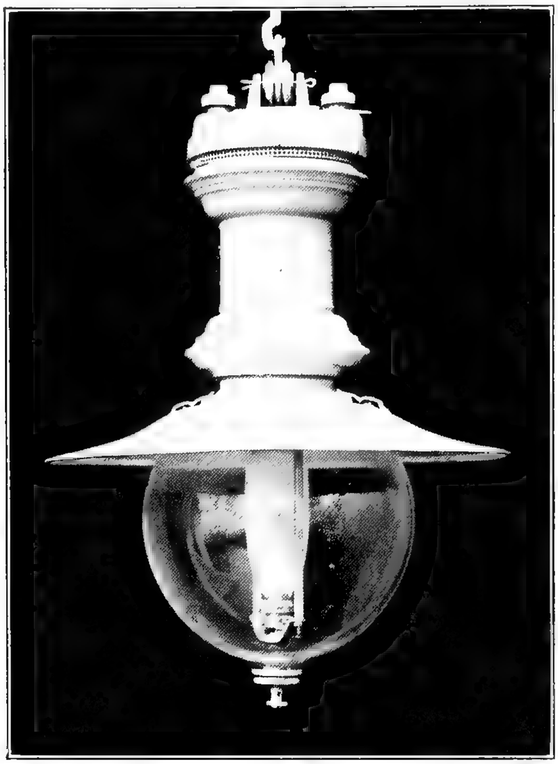
This record of the lineal descendants of the ancient torches and "linkboys" would not be complete without some reference, supplementing remarks already made above, to the efforts at street illumination

Bishop's Crook Arc Lamp Post

with incandescent lamps, whose use for such a purpose once quite precarious, never ceased, and now has attained such brilliant success, that the arc lamp may never again reconquer its proud supremacy. In America, at one time, the old arc lighting companies, fostered almost exclusively to enjoy highly remunerative street lighting contracts, blocked the way quite seriously in appearance but not in actuality, of the development of incandescent lighting. The incidental rivalry was often bitter to the point of ferocity. The great National Electric Light Association was once the advocate and exponent of American arc street lighting interests, to the virtual exclusion of incandescent lighting; but that phase passed, especially with the coming of practical electric motors, the demand for electric service in the home and factory, and the introduction of the alternating current. Perhaps it all, aside from the powerful personalities involved both in invention and manufacturing, may be said to be keyed upon the greater success of the multiple or parallel method of incandescent operation as opposed to the series arc method. The final joint victory of both worked out in modern alternating current methods for generation rather than simply in supply, both pioneers surviving the struggle, and little being lost or discarded in the startling demonstration of the principle of *solvitur ambulando*.

Typical of the occurrences at a time when the fierceness of the early struggle between arc and incandescent systems was most intensified, Edison brought out his "municipal system," whereby the Edison light can be distributed over large areas with the minimum investment. Such a system has been worked out and experience with it has shown that a fair profit can be made by the local companies on contracts for the lighting of public streets, parks, etc. In this system, each incandescent lamp was mounted on a pole, screwed into a socket, protected against rain by a metal hood in the supporting bracket, and associated with a simple device which closed the circuit whenever a lamp was burned out, thus maintaining the continuity of the circuit as a whole, until the defective lamp could be replaced, and the compensating resistance taking its place at the central station removed. The system operating at 1,000 volts was analogous to the arc system in its applicability to long lines, and was fairly tried out, but gave way before the more flexible methods of the alternating current in its modern application.

For some time all these systems of street lighting, both arc and incandescent, and notably the former, were subject to the reproach of marring the vista of any street by the introduction of long lines of ugly poles and untidy stretches of circuit wire. Light and police protection were secured at the expense of beauty. But gradual æsthetic improvement came. The lighting wires and cables were placed underground, and poles and fixtures of an ornamental character took the place of much that was disorderly and untidy. Europe may be said to have gone further in this respect than America, but many famous thoroughfares on this side of the ocean might now be cited as illustrations of successful attempts to associate without the sacrifice of any essential element of either, brilliant illumination with beautiful architecture. Indeed some highways of commerce and social life are seen to better effect by night than by day.



Alternating Current Arc Lamp—Enclosed Type

CHAPTER II

STORY OF THE INCANDESCENT LAMP

IN the historic experiments with the electric arc made in 1808-10 by Humphry Davy with his battery of two thousand voltaic cells and his strips of charcoal, may be found the germ of incandescent, as well as of arc, lighting. For after recounting his experiments and discoveries in connection with the arc itself, he continues:

"And a platinum wire, one-thirtieth of an inch in thickness and eighteen inches long, placed in circuit between bars of copper, instantly became red hot, then white hot, and the brilliancy of the light was insupportable to the eye."

After that, numerous investigators made application of the incandescence of platinum in the production of light. Tesse du Motay, the French chemist, employed platinum sheets and foil made incandescent in the hydrogen flame. De Moleyns, in England, secured the first patent for an incandescent lamp in 1841. His plan proposed to sprinkle finely divided carbon or graphite over the surface of the incandescent platinum wire, to add to the brilliancy of the light.

Most of the early inventors produced the incandescence in the open air, but some of them used a Torricellian vacuum. Torricelli discovered that mercury in a glass tube at sea level would stand at a height of thirty inches, when a tube of that length was inverted and stood upright in a vessel of mercury. Starr and others of the early inventors utilized a tube six or eight inches longer than this, filling the entire tube with mercury, so that when the tube was inverted (as already described) the mercury would fall until it reached the height of thirty inches, leaving a Torricellian vacuum above. It was this vacuous space which some of the early inventors used for their electric lamps.

The inventor, J. W. Starr, just referred to, was a young American from Cincinnati, and a protégé of George Peabody, the famous philanthropist and banker. Mr. Starr, in 1845, took out an English patent in the name of his British attorney, King, for a lamp, consisting of a strip of carbon in a Torricellian vacuum. This young man died in 1847 (the year of Mr. Edison's birth), but in the same year, a few months before his death, he had the satisfaction of exhibiting his invention before Professor Faraday. The form of the exhibit was an electrolier containing twenty-six lamps (representing the twenty-six states into which the United States was then divided), and the great scientist expressed marked approval of the young man's achievement.

Gardiner and Blossom, in 1858, took out the first American patent in this field. This patent was for a platinum lamp to be used as a railway signal lamp. One of these is still preserved in the Patent Office at Washington.

Important experiments in the incandescent lighting field were early made by many investigators, including Konn, Kosloff, Bouliguine, Lodyguine, Staite, Fontaine, Draper, Adams, Watson, Farmer, Roberts, Sawyer, Maxim and others. Their work brought increased knowledge

of the subject, even though none of them succeeded in evolving a commercially successful incandescent lamp. Nearly all were separable lamps, and all had inherent defects. Most of them burned in the open air, and others were sealed by glass or porcelain. Probably none of them was exhausted except such as used a mere Torricellian vacuum. Limitations of space prevent giving details of all this work.

Major William J. Hammer, lately in United States service, but who was one of Mr. Edison's early laboratory assistants and subsequently electrician of the first Edison lamp factory, furnishes some most interesting data in regard to the early platinum lamps, in a lecture delivered by him at the 317th Meeting of the New York Electrical Society, held February 17, 1913. He says:

"The early platinum lamps were very limited in their possibilities; for if platinum is brought up to over 3 to 4 candles, its melting point is reached and it softens like butter. Edison's first lamp was a platinum lamp, but he alloyed iridium with the platinum, as had been done by Staite before him, and the use of which had been suggested by Petrie. Edison found that by gradually heating the wire by means of an electric current, then allowing it to cool, and reheating and cooling it again many times, he was enabled to drive out the hydrogen gas which was occluded in the pores of the metal; and the metal became exceedingly dense, and so hard that the sharpest file would not affect it. It was like a new metal, and a spiral coil, which had a radiating surface of three square inches, could be raised to from 30 to 35 candle-power without melting. A thermostatic wire placed in the center of this spiral was attached to a short-circuiting lever, so that an excess of current sent through the spiral would heat and expand this thermostatic wire, allowing its lever to touch a contact which short-circuited the spiral. As soon as the spiral had cooled sufficiently, the thermostatic wire would lift the lever, thus throwing the spiral back into circuit again. This lamp was known as Edison's platinum-iridium thermostatic regulating lamp.

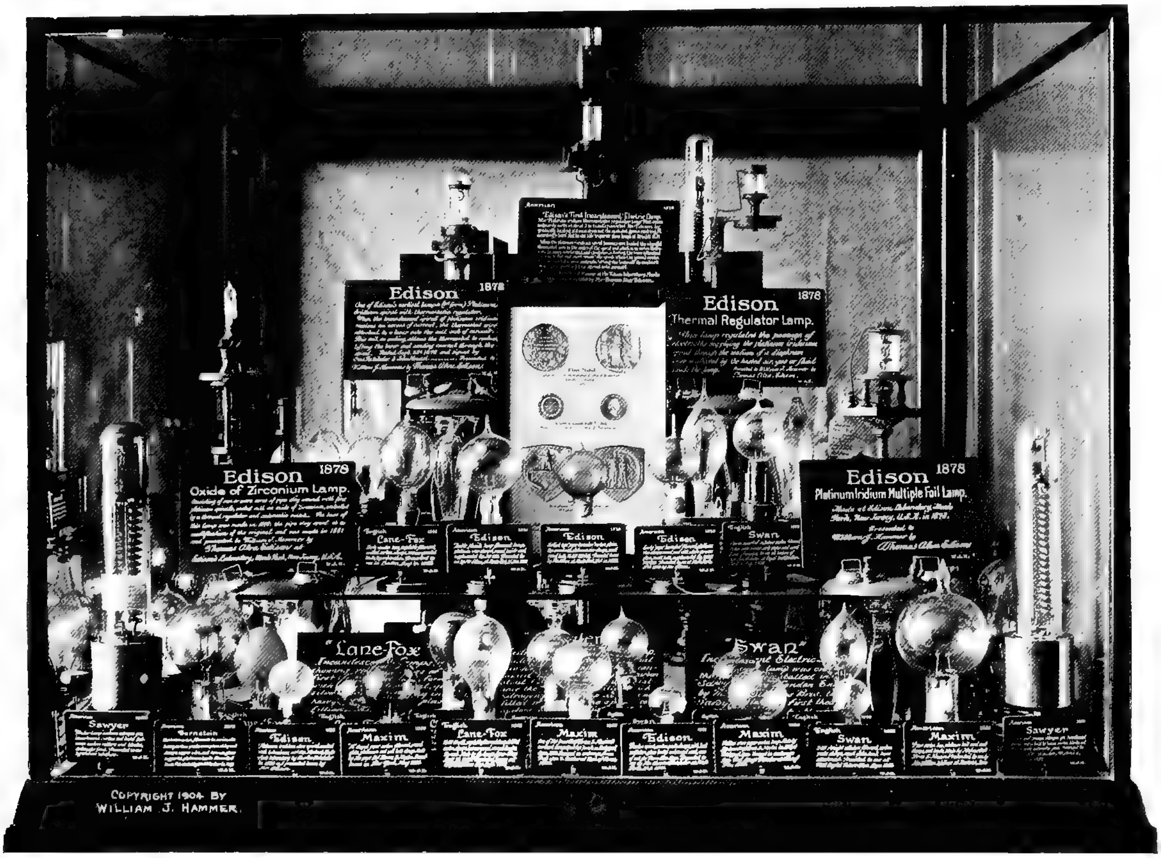
"In this early work of Mr. Edison, 1877-1878, he not only employed platinum in the form of wire and foil and alloyed it with various metals, but he did considerable work with various metallic oxides. Among his early lamps was an oxide of zirconium lamp; another lamp shows a platinum wire coated with titanium oxide."

Thomas Alva Edison is justly and universally recognized as the father of the commercial incandescent electric lamp, yet when he introduced his incandescent ? lamp into general public use in 1870, the filament he used in his lamps was only a fine string of charred paper. A contemporary newspaper account well expressed the sentiment of intelligent people of that day when it said: "Were it not for the phonograph, the quadruplex telegraph, the telephone and various other remarkable productions of the great inventor, the world might well hesitate to accept his assurance that such a beneficent result had been obtained, but, as it is, his past achievements in science are sufficient guarantee that his claims are not without foundation, even though for months past the press of Europe and America has teemed with dissertations and expositions from learned scientists ridiculing Edison and showing that it was impossible for him to achieve that which he has undertaken."

Mr. Edison began his researches and investigation in incandescent electric lighting when he was a young man, barely thirty years old. He had already made himself famous as a epoch-creating inventor, and in turning to the subject of electric illumination he had his choice between taking up the improvement of arc lighting, already being commercially exploited in a somewhat feeble, but still effective way, or to try his hand at the problem of producing an incandescent light that could really be made a commercially practical and socially useful thing. Others had devoted thought and research to the problem, and had demonstrated that incandescent light of much brilliancy could be produced, but each was far from producing anything that could compete on even terms with gas lighting or even the crude arc lights of that time. That a practical incandescent light must be one so cheap that it could so compete was one of the most important goals recognized by him, and as a corollary to that was the consideration that the light to be

evolved must be pure, steady, brilliant and reliable.

Like the others, he harked back to the experiment of Sir Humphry Davy and his platinum wire that glowed so brightly that the eye could not support the brilliancy. At this stage it was that he used the expedient of copper electroplated with gold receiving the heat rays from a platinum-iridium spiral and reflecting them upon a thin piece of oxide of zirconium which became vividly incandescent with a light much more brilliant than that of the spiral itself. Many experiments and modifications ap-



The lamps in this case (No. 1). of the William J. Hammer Historical Collection of Incandescent Electric Lamps, represent the foundation of the Art and include the initial work of such early inventors as Edison, Swan, Lane-Fox, Changy, Lodyguine, Sawyer, Maxim, Bernstein, Cruto, Muller, Crookes, Swinburne, Boehm, Latimer, Akester, Nothomb, Siemens and others from 1878 to 1883.

of an iridium alloy and a thermostatic regulating wire. But his "platinum-iridium thermostatic regulating lamp" was not satisfactory. After he had patented it he found that the constant expansion and contraction of the platinum and the pressure upon the regulator, bent the metals so that the lamp was variable and not reliable. Other forms of platinum lamp and suitable modifications of the regulating device were tried. One of the devices given a trial was a reflector lamp—a polished reflector plied to this lamp satisfied Mr. Edison that it did not meet his objectives.

Some study and effort was applied to the idea of isolated installations for each householder to produce his own light by the use of induction coils operated by two cells of battery, and Mr. Edison succeeded in securing a light of several candle-power with the use of a moderately powerful coil, but he decided that the light was not the one he was aiming to produce.

Later he made experiments with osmi-

um-iridium in the native alloy known as iridosmine, which he used in powdered form inclosed in a tube of oxide of zirconium. He secured a brilliant incandescence from this, but again it did not fill his requirements as a lamp suitable for general illumination.

Mr. Edison then made some experiments with carbon as a filament in connection with platinum. He employed a slender rod of carbon, the inferiority of contact at the meeting point of the two rods producing a degree of resistance causing the carbon to become highly incandescent while the platinum maintained only a dull red heat. The carbon rod was kept pressing upon the platinum by a weight ingeniously arranged. He made a dozen or more forms of this lamp, but decided to return to platinum as the medium of incandescence, and worked day and night at it for about two months, only to find that platinum and iridium alloy and all the various metallic substances he had been using as media for the glow deteriorated from atmospheric contact and lost weight, and after many repeated exposures to high temperatures followed by cooling, the metal fell to pieces. He thus arrived at the heart of his problem, which was the exclusion of air from the incandescent metal. A spiral wire or other form of platinum was placed in a glass tube or bulb, with the wire near its ends passing through and sealed in the glass after the air had been exhausted from the glass. He found a wonderful change after he adopted this plan.

Where, during his experiments, he had attained a luminant intensity of about three standard candle-power, he now, with the same amount of current, secured from the wire in vacuo a light equal to twenty-five candle-power. The cracking and deterioration of the metal which had resulted from the alternate high temperature and cooling of the surface of the wire no longer occurred.

He also experimented with the alloy of platinum and iridium coated with oxide of magnesia. He had tried this before with exposure to air and found that when he had raised the coated metal to incandescence of about four candle-power the metal melted. But in a vacuum tube a combination took place between the metal and the oxide, giving the metal remarkable properties. With a spiral having a radiating surface of three-sixteenths of an inch a light of forty-candles could be obtained. The effect of the oxide of magnesia was to harden the metal to a remarkable degree, and to render it more refractory.

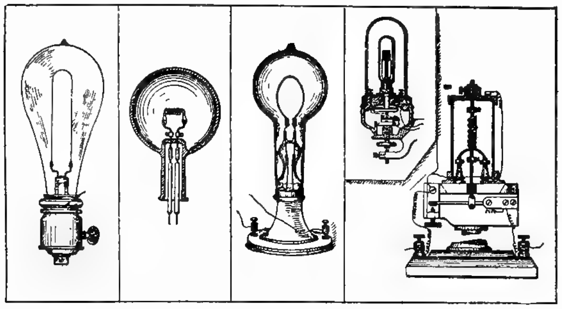
At about this point Edison discovered that economy in the production of light from incandescence demanded that the incandescent substance should offer a very great resistance to the passage of the electric current; and to that end he found it necessary to reverse the existing practice of having lamps of only one or two ohms resistance, and construct lamps that, when giving their proper light, should have, say, not less than two hundred ohms resistance.

In turning out his first platinum vacuum lamp Edison had traveled a long way on his quest. But the production of the lamp was only a small part of his labors. He had to perfect an air pump until it would create in his lamp bulbs a vacuum so nearly perfect as to represent only about one-millionth of an atmosphere. He had also to work out the problem of a generator for electricity which would deliver in electricity about ninety per cent of the energy it received from the driving engine.

THE INVENTION OF THE INCANDESCENT LAMP FILAMENT

Just after he had completed his platinum vacuum lamp one of those apparently trifling things occurred which have at various crises in history turned out to be starting points on the road to large success. Bruce and his spider, and Watt and his tea-kettle are familiar examples. Edison was sitting in his laboratory pondering over one of his problems, and happened to have in his hands a piece of compressed lampblack mixed with tar for use in his telephone transmitter. Mechanically he was rolling this substance in his fingers until it became a slender filament. Happening to glance at it, his mind connected it with the problem of his lamp, and he wondered how this delicate carbonaceous strand would act if made incandescent. The trial was made with a result which,

while not sensational, was satisfactory. It gave the inspiration to try similar substances until one that would meet his requirements should be found. A spool of cotton was lying on a table in the laboratory. Edison cut off a small piece, put it in a groove between two clamps of iron and placed them in the furnace. His experiment with the tarry lampblack had suggested to him that some carbon filament of a texture not yet tried might prove to be the ideal agent of incandescence for the lamp. Removing the iron mould from the furnace after an hour's subjection to its heat, he let it cool and then took from it the delicate carbon skeleton of the cot-



Earlier Forms of Edison Incandescent Lamps

ton thread, placed it in a globe and connected it to wires leading to his generator. He extracted the air from the globe, turned on the current, and the film became beautifully incandescent. He turned on more current and still more with no worse effect than increased intensity in the light. Finally he turned on the full current and the frail filament emitted a light equivalent to that of several gas jets, but soon quivered and broke in twain. A microscopic examination of what remained showed the surface of the filament to be highly polished and its parts interwoven with each other. The experiment had proved that this flexible filament was much more infusible than platinum, then looked upon as the most infusible of metals. The filament had as the result of the strong currents of electricity to which it had been subjected, acquired a remarkable degree of hardness compared with its fragility, before it had been placed in the lamp.

Edison forthwith worked night and day to perfect his idea of making each of his lamps an independent self-contained unit, consisting of a high-resistance filament of carbon, hermetically sealed in an all-glass receptacle with platinum leading-in wires. Everything about it had been completed except the selection of the exact type of carbon filament for the lamp. From carbonizing pieces of thread he turned to splinters of wood, straw, paper and other substances never before used for such purpose.

The result of this series of experiments was the adoption of paper. All kinds of paper were tried and all were found to possess good qualities, but the best results were obtained from "Bristol" cardboard, which was adopted as the material for the filament of the lamp as introduced and commercialized. In developing this lamp Mr. Edison devised ingenious means for carbonizing and inserting the horse-shoe-shaped delicate filaments. A partial enumeration of the substances tried includes electric arc light carbon made into paste and rolled into threads, cotton thread, vulcanized fiber, carbonized flax, threads made of lampblack and tar, linen, cardboard, soft paper, fish line, various combinations of paper and tar, celluloid, boxwood, cocoanut hair and shell, shavings from hickory, baywood, rosewood and many hundreds of other varieties of wood, lamp wick, punk, cork, bamboo fiber, and many others.

The lamp was perfected October 21, 1879, at Edison's Menlo Park, N. J., Laboratory. On that day the first such lamp was put in circuit, and maintained its incandescence for over forty hours. On December 31, 1879, only three months later, Edison gave a public demonstration of his electric lighting system in streets and buildings at Menlo Park using underground mains. This involved the use not only of the generator and lamps of Edison's invention, but also of sockets, switches and all the accessories of a central lighting station and system. The goal of central station lighting had been reached.

Early in 1880 Edison installed upon the new steamship "Columbia," built at Chester, Pa., in 1879, the first Edison incandescent lighting plant that was ever installed for commercial use, although a small plant had been put in 1879 on the

"Jeannette," which was lost in the Arctic regions. The installation, which was made in New York Harbor, consisted of three 60-light Edison dynamos, the field magnets of which were separately excited or energized from a fourth machine. There were 115 lamps in this pioneer installation. The distributing system embraced bus-bars, switches, feeders, and mains, all well protected by fusible cutouts. It was similar in essential particulars to modern installations. The lamps of this "Columbia" installation had the paper filament.

Edison introduced his lamp with the paper filament because that was the best available at the time, but he determined to find a better one. To quote his own words, "We saw that carbon was what we wanted. The next question was, what kind of carbon? I began to try various things and finally carbonized a strip of bamboo from a Japanese fan and found what we were seeking." Major Hammer tells us that Edison used bamboo for his filaments for many years. "There are said to be some three thousand varieties of bamboo, of which about four hundred are of some particular use, the rest being largely weeds. Edison found in a hilly district of Japan a variety of bamboo called 'Madake' and discovered that when the outer calcareous surface and the inner pithy fibers were removed, he obtained in the center one of the most perfect cellular structures known, which produces a carbon filament of great strength and high resistance."

Speaking of his entrance into the field of electric light, Edison has said that the idea struck him all of a sudden. "In those days there was an outfit of one or two arcs traveling with a circus. It was easy to see what electric lighting needed—it wanted to be subdivided. The light was too bright and too big; what we wanted was little lights, and to distribute them to people's houses like gas." This statement is reminiscent of the days when even the arc light was a curiosity. Dan Rice's Circus, which exhibited the arc light as a great curiosity through the country in the middle seventies, attracted large crowds of admiring spectators by this crowning novelty.

Edison's preliminary concept included, first, a dynamo with low resistance armature; second, a high resistance lamp, of relatively small candle-power; third, a distributing system on which the lamps would be connected in multiple instead of in series.

If the scientific world was reflected in the scientific press, it believed each of these projects impossible. The subdivision of the current in multiple was almost unanimously counted as an impossible thing. The announcement of the invention of Edison's dynamo was criticised as being "so manifestly absurd as to indicate on the part of writer and promoter a positive want of knowledge of the electric circuit and the principles governing the construction and operation of electrical machines."

Professor Charles F. Chandler of Columbia University thus describes the problem of distribution which confronted Edison after he had invented the incandescent lighting system: "There was no method known, prior to 1880, by which large numbers of electric lights of a power about equal to a gas burner could be practically operated over large areas. The problem necessary to be solved, in order to render electric lighting with lamps of low candle-power in large numbers feasible, was to design a system of distribution by which the current necessary to operate the lamps could be economically sent great distances to all parts of the district and be supplied under proper regulation of the lamps, irrespective of the number used, and whether far or near to the source of electricity. In accomplishing this result, the lamps must be individually under the control of the user, and this without affecting the current supply of the lamps; also the conductors must be of sufficiently moderate size to bring the cost within commercial limits.

"When Edison first attacked the problem of incandescent lighting, he was met with the objection of all electrical authorities that a durable incandescent lamp could not be made. When he proposed to subdivide the current * * * he was warned on all sides that he was in pursuit of an impossibility—the thing could not be done. After he had produced the desired lamp and subdivided the current experimentally, his critics not less confidently asserted that a laboratory experiment was one thing, the practical application of the theory to a

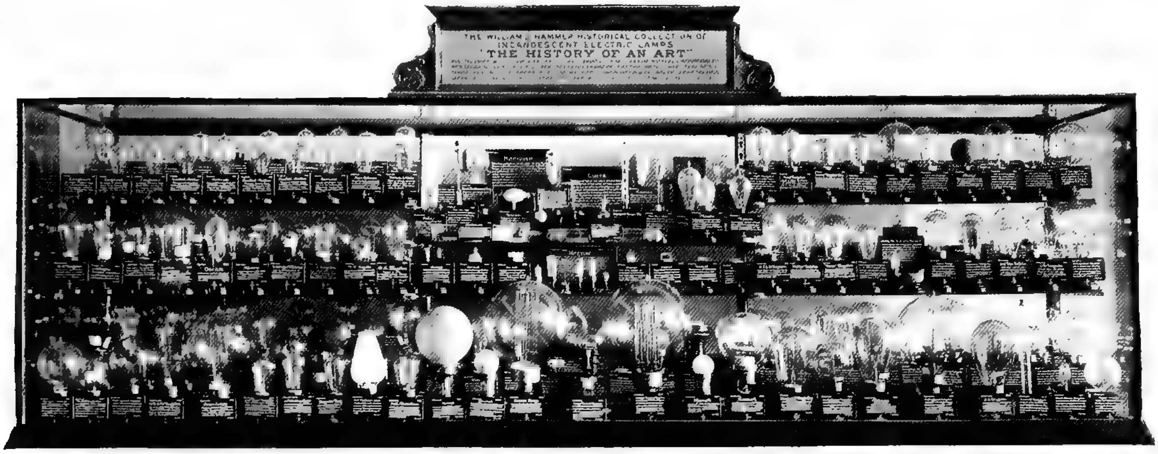
complex system of public service was quite another, and he was bound to fail. It was a question of economy, and, admitting that an incandescent light could be furnished under the conditions required, it would not pay."

In connection with his invention of the incandescent lamp Edison had increased the efficiency of the dynamo from 40 to 90 per cent, another of the things which scientists had considered an impossibility, and had developed the apparatus necessary for incandescent lighting service.

MAKING THE INCANDESCENT LAMP

Manufacturing lamps was first conducted at Menlo Park in 1880, and in 1882 Edison removed his lamp works to Harrison, N. J. The blowing of the glass bulb was at first performed by hand, and this practice continued until 1892, when the manufacture of molded bulbs was begun. It is remarkable that up to now, no radical change in the general method of manufacture has been made, though great improvements have been introduced in the filament, in the life and efficiency of the lamp, and in the uniformity of the product.

The development of the filament measures the highest evolution of efficiency in the incandescent lamp. The life of the filament of carbonized paper was about forty hours, on the average. The efficiency of that first lamp was approximately seven watts per candle-power or about nine lamps of sixteen candle-power per kilowatt or 6½ lamps per horse power. After the carbonized strips of bamboo were adopted as a filament the efficiency was increased to five watts per candle-power, (12½ lamps per kilowatt, 9 1/3 per horse-power). In 1891 various improvements resulted in an increase of the efficiency of the lamp to 3.1 watts per candle-power (20 lamps to the kilowatt or 15 per horse-power), the filaments being still made of bamboo. During 1892 the process was adopted of "treating" the filaments by depositing on them a dense coating of graphite carbon, insuring a uniform cross section throughout its length. The useful life of the lamps was also thereby increased, as the denser carbon filament decreased the blackening of the bulbs. It may be noted that the Sawyer-Man lamp used this treating process from 1880 onward.



The lamps in this case, which is one of the five comprising the William J. Hammer Historical Collection of Incandescent Electric Lamps, represent the Art under the workers contemporaneous with Edison all over the world from 1910 to 1913 other than the carbon filament lamp, and embrace the developments along the line of rare metal and metallic oxide filament lamps, and also embrace a section which points the way toward the ideal "cold light."

The improved form of filament, an oval with a short center anchor to support the loop, was adopted during the year 1894, which more than doubled the tip end candle-power of the lamp, resulting in a more uniform distribution of light in all directions. The use of a waterproof cement in place of plaster of paris to fasten the base to the lamp bulb was also a val-

uable improvement, by means of which lamps can be safely exposed to the weather. A still more important, because generally applicable improvement of that period, was the introduction of the chemical process by which the final traces of air are removed from the bulb.

About 1905 came the introduction of the Gem filament, an ordinary carbon filament subjected to the intense heat of the electric furnace, which increased the refractory quality of the carbon, raised the efficiency to 2½ watts per candle (equal to 25 lamps of 16-candle-power per kilowatt), and increased the useful life of the lamp to a considerable extent.

With improvements in manufacture of lamps there came a very noteworthy increase in the use of electric light and a most material reduction in the price of the carbon lamps.

DEVELOPMENT OF METALLIC FILAMENT LAMPS

During all of the development of the incandescent lamp there had been constant experiments to find a metal suitable for filaments which should at once have higher efficiency and longer life than the best carbon filaments. In 1906 the tantalum lamp, with an efficiency of two watts per candle (equal to thirty-one 16-candle-power lamps per kilowatt) was first placed on the market in America. The life of this lamp was soon found to be much shorter on alternating than on direct current circuits, and its life decreased in ratio with the increase of the frequency of the circuit alternations—characteristics which greatly retarded its adoption for general use.

This lamp soon disappeared from the American market because of the much higher efficiency of the tungsten lamp which appeared in 1907, and is now universal. In size such lamps have been carried to proportions and candle-power rendering them formidable and successful rivals with the largest arc lamps for the illumination of extensive areas. The economy and efficiency of the ordinary tungsten lamps is so high that the Fuel Administration in 1918, in cooperation with the central stations and the lamp manufacturers of the country, took steps which involved practically the abandonment of all other types, except those needed for special service and of superior ruggedness for such use as in the navy, forts, etc., and in some classes of apparatus and instruments. The handicap of greater cost in production under which the tungsten lamp labored for some time has also virtually disappeared.

Dr. Charles Baskerville, late professor of chemistry and director of laboratories of the College of the City of New York, made an intensive study, chemical and historical, into the evolution of the tungsten lamp. While from 97 to 99 per cent of the tungsten produced is used in the steel industry, there is no use of it which is more interesting than its application in the manufacture of filaments for electric incandescent lamps. The use of this metal for that purpose has, in fact, revolutionized the lighting industry. In fact, Prof. Millikan, of the University of Chicago, has gone so far as to say: "One little new advance like the discovery of ductile tungsten, which makes electric light one-third as expensive as it was before, is a larger contribution to human well-being than all kinds of changes in the social order."

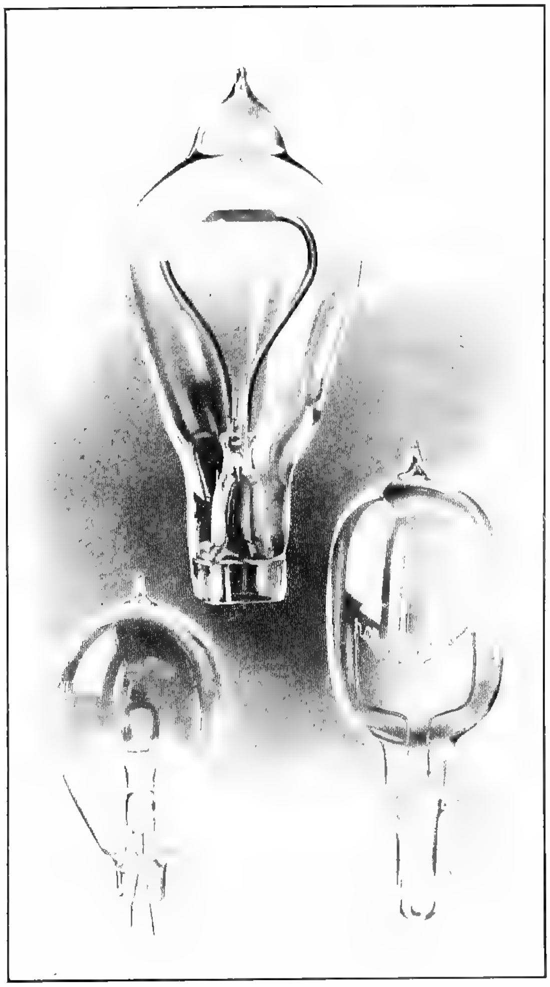
Writers on the history of tungsten as a lamp filament have almost unanimously given to Austrian inventors the credit of the invention of the tungsten electric lamp filament, in 1903. But Dr. Baskerville, while conceding to the Austrians much of the credit for the development of the tungsten filament, asserts that Turner D. Bottome, an American, is entitled to the credit of priority of invention. Mr. Bottome, in the early part of 1887, conceiving the idea that tungsten was a metal especially suitable for an incandescent lamp filament, being of fairly high resistance and of high melting-point, made experiments to that end.

"During the development of Bottome's invention," said Dr. Baskerville, "some parties made strong efforts to get possession; but, through the assistance of J. B. Tibbits, of Hoosick, N. Y., the patents were secured. Bottome's application was filed on September 29, 1887, and was allowed on April 9, 1889, the issue number being 401,120. Bottome also took out a

patent for treating the filament, dated August 6, 1889, and numbered 408,286. Tibbits assigned the English rights of the invention to H. H. Lake of London, and English Patent 6,104, April 9, 1889, relates to a method in which a carbon filament is prepared in the ordinary manner and then soaked in a saturated solution of tungsten trioxide dissolved in any of the fixed alkalies, after which it is rendered incandescent by a current of electricity in an atmosphere of pure dry hydrogen, the result being that metallic tungsten is deposited upon it, 'which makes it tougher and more durable.' It is apparent, therefore, that Bottome devised a process of utilizing refractory tungsten for coating carbon filaments, thus being the first, to my knowledge, to make use of tungsten in the production of filaments for incandescent electric lamps."

The development of the tungsten lamp, however, begins with 1903. The extreme brittleness of tungsten filaments as first manufactured was the great drawback to their use. The loss from shock was very great. This defect was the most important among those which inventors set out to remedy, and fifty patents along that line were granted by Germany alone from 1903 to 1908. Just and Hanaman (German patent September 8, 1904,) planned first to produce a coating of tungsten on a core of carbon or metal, which was accomplished by heating the carbon or metal filament to incandescence in an atmosphere of tungsten oxychloride vapor with an excess of hydrogen, by which means the reduced tungsten was deposited on the filament, which then became a core of carbon or metal with a sheath of tungsten. Later patents by the same inventors sought by modification of the reduction process to get rid of the carbon by oxidation and substitute tungsten. This was known as the "substitution method" first specified in Just and Hanaman's French patent, Nov. 4, 1904, in which the patentees made modifications in their British and German patents, 1905, and in their United States patent, 1908.

In spite of modifications of the process it was found to be practically impossible to secure thorough removal of the carbon, and a "paste" method was adopted in a French patent, 1905. Tungsten compounds reducible by hydrogen were pulverized and mixed with a binding material free from carbon, formed into a paste, pressed into filament form and reduced in an atmosphere of hydrogen. Supplements to their earlier patents in France and Germany pro-



Historical Sawyer-Man Lamps

vided for small alloys of more readily fusible metal, such as chromium, vanadium, tantalum, etc., to overcome the fragility of filaments made under Just and Hanaman's original patents. Hans Kuzel, and Carl Auer von Welsbach (famous inventor of modern methods of both gas and electric lighting) introduced new processes. The Austrian Welsbach Company was among

the first to place tungsten lamps on the market for voltages of from 100 to 120, and tests of the lamps showed them to operate well even up to 1,000 hours of burning. Siemens & Halske, of Berlin, also took out numerous patents on the manufacture of electrical glow-lamps with incandescent bodies of tungsten.

In this connection, Mr. Paul McJunkin, of Chicago, furnishes under date of January 31, 1919, some very interesting data and comment as follows: "In March, 1906, I visited Vienna and saw some lamps and filaments of pure tungsten burning in the laboratory of Johann Kremenezky, and in April I brought three of them back to New York, where they were of great interest to various of my friends, who then saw them. I believe it was many months later that the first lamps with the so-called 'pressed filaments' were brought to this country. The lamps first referred to had filaments made by the colloidal process developed by Dr. Hans Kuzel. The method of manufacture was a guarantee of extreme purity, in that the tungsten was precipitated from solution in the highest state of chemical purity possible, and the very finely divided metallic tungsten was pressed into threads, dried, and then by the passage of an electric current, sintered into a homogeneous tungsten filament. The binder which held the tungsten particles together during this treatment was pure colloidal tungsten as opposed to carbonaceous binders later used; hence there were absolutely no impurities of any kind to be removed. The great difficulty of the process was its rather high cost. That these filaments were undoubtedly of the highest degree of purity is also attested by an extensive series of life tests made in 1906 by the Gewerbe Museum, the national testing laboratory of Austria. These tests, of unquestionable authority, have never been surpassed, if equalled, by any vacuum type of lamp which I have even seen. Hence, although it may not have been possible to reduce the colloidal process to a commercial basis, at least to compete in cost with those later developed, Dr. Kuzel should be credited with having been the first to reach the long sought goal of a pure tungsten filament."

As to the production of ductile tungsten, Mr. McJunkin says: "In connection with the development of ductile tungsten and the manufacture of wire thus made possible, credit should by all means be given to Mr. A. J. Langelier, of Providence, R. I. The one most essential step was to produce a fibrous structure in the otherwise extremely brittle crystalline mass of the tungsten. Mr. Langelier's years of experience in swaging various metals convinced him that if it were possible to produce the required structure it would be by swaging an ingot of tungsten at a very high temperature. Against the advice of those working on the matter, Mr. Langelier finally secured some of these ingots and produced rods which could eventually be drawn to wire."

In regard to the gas-filled lamp, Mr. McJunkin says: "Would it not be well to credit Messrs. Phillips, of Endhaven, Holland, who, I believe, introduced the use of argon instead of nitrogen in lamps of low voltage, or, rather, low amperage? This made possible the successful production of gas filled lamps as small as 40 watts, 112 volts, and improved all lamps below 100 watts, 110 volts. In this country, the work of Mr. C. H. Humphries enabled the Lux Manufacturing Company to put on the market 40 watt lamps as early as 1915."

Mr. McJunkin is to be thanked also for one final suggestion as to osmium, and says: "In your brief reference to the tantalum lamp, as a short lived precursor of the tungsten lamp, would it not be well to mention the osmium lamp as well? Although never used in this country, several millions were used in Europe. The efficiency was comparable with that of tungsten lamps, but due to the extreme fragility of the filaments and the very small amount of osmium available they were immediately replaced by even the earlier tungsten lamps."

American contributions to the continuing development of the tungsten lamp have, however, been of great importance and represent the highest achievement in incandescent lamp efficiency. Dr. Baskerville has described them in part as follows:

"In the process used by the Westinghouse Metal Filament Lamp Company a mixture of 400 grams of tungsten trioxide and 800 grams of powdered zinc were

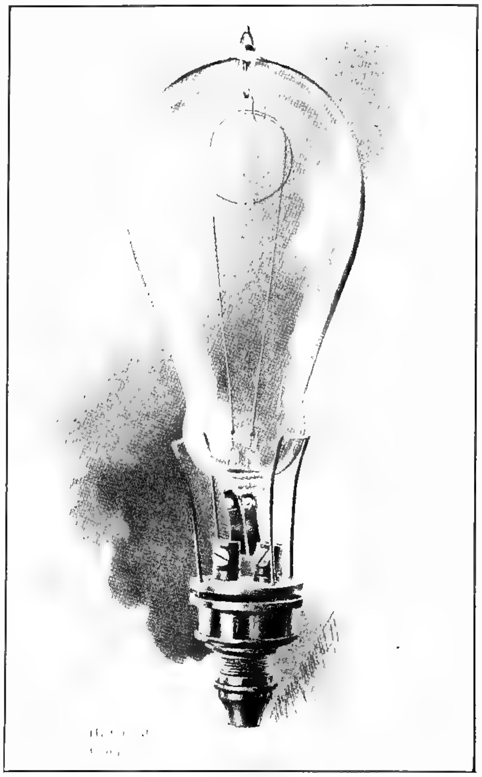
heated to 800° C. for an hour. The powder was pulverized after cooling and then treated with a half-litre of hydrochloric acid (1.12) and a small amount of nitric acid. After repeating this, to remove all the zinc and zinc-oxide, the acid was expelled and the mass washed. It was then evaporated to the consistency required for squirting into filaments, which were heated in a furnace to 800° C. for thirty minutes. After cooling, they were treated with an electric current to a white heat in an atmosphere of nitrogen or hydrogen.

"The development of the processes of the General Electric Company has been of the greatest interest. In 1906 this company claimed a process wherein 'nitridamide' of tungsten was mixed with a carbonaceous binder, the carbon being removed by oxidation. In the same year the use of cadmium amalgam was introduced by Coolidge, the volatilizable metals being expelled by heat after being squirted into filaments; and then an alloy of bismuth and cadmium was proposed in place of the amalgam, and later an alloy of cadmium and lead was used as the binding material.

"Whitney hit upon the idea of compressing tungsten powder, which had been prepared by reducing tungsten trioxide in hydrogen. On subjecting tungsten powder, placed in a mould, to a presure of about three thousand pounds to the square inch it was found that the particles adhered sufficiently to admit of handling as one piece.

"The pencil or rod thus produced is inserted in a powerful electric circuit and heated by the passage of the current until the particles sinter together (about + 2,650° C.). The device is most ingenious. One end of the rod is attached to a copper disc which floats upon a cup of mercury, acting as one terminal. The other end is attached to a leading-in copper wire which, duly insulated, passes through a water-jacketed copper bell-jar, which rests in a tank of mercury. Hydrogen is driven into the apparatus under sufficient pressure to cause it to bubble through the mercury at the bottom. One may imagine, if not perceive, the brilliancy of a rod one centimeter in diameter and twenty centimeters in length as it approaches the melting point of tungsten with the increase of the current. The rod becomes solid metal and is subsequently heated and swaged in an atmosphere of hydrogen. When of a sufficiently small diameter, the wire is drawn through diamond and, more recently, alundum dies. By thus transforming tungsten into a ductile metal these experiments of Dr. Whitney have created a new era of higher efficiency for the incandescent electric lamp."

Before closing this very interesting section of the narrative, a striking statement



Early Sawyer-Man Lamp

as to a fact not at all generally known may be credited to Mr. Paul McJunkin, as follows: "As a matter of fact, I believe de Lodyguine working in Pittsburgh for Mr. Westinghouse came nearer than anyone else to securing a pure tungsten filament; but he barely escaped fame and fortune."

The history of the radical and sweeping change in the art due to the adoption and perfection of the drawn wire tungsten filament, which now reigns supreme in the field of incandescent lighting, was summed up by Mr. J. E. Randall in a paper read

before the Illuminating Engineering Society at Chicago in September, 1911, when he said epigrammatically: "In 1907 it was hoped that it would be possible to produce ductile tungsten; in 1908, it was believed that it would be possible to produce ductile tungsten; in 1909, experimenters were sure that ductile tungsten could be produced; in 1910, it had been proven beyond doubt that ductile tungsten could be produced; in 1911, ductile tungsten was produced on an extensive commercial scale." The report of the Society's Committee on Progress in the following year, 1912, remarked sententiously: "The most important change of the past year in electric incandescent lighting has been the very widespread adoption of the drawn-wire tungsten filament."

The latest improvement, it may be added, worked out by the Schenectady laboratories of the General Electric Company, in connection with incandescent electric lighting was the introduction, in 1913, of the gas-filled lamp known as Mazda C. It was found that when a coiled tungsten filament is operated in an inert gas such as nitrogen, it could be operated at a much higher temperature and consequently at a higher efficiency, at the same time retarding the evaporation of the filament and prolonging its life. In October, 1922, the U. S. courts sustained the validity of the Just and Hanaman tungsten filament lamps and the Langneur gas filled lamp patents of the General Electric Company.

The report of the Lamp Committee of the National Electric Light Association for 1920 stated that the total sales for domestic use of incandescent lamps in 1919, excluding miniature types amounted to 183,000,000, of which no fewer than 170,000,000 were tungsten; and all of the tungstens, it may be added, were of drawn-wire. The latest chapter of incandescent lamp manufacture is therefore already well advanced in its historical and industrial development. Of the 170,000,000 tungstens, 143,000,000 were of the vacuum type, and no fewer than 27,000,000 were of the gas filled type. But it is significant that the gas filled type while only 15.9 per cent of the sales, were no less than 42 per cent of the total candle-power.

GASEOUS CONDUCTION LIGHTING

In the early nineties, D. McFarlan Moore concentrated his energies and inventive abilities on the field of electric lighting by gaseous conduction and on the production of a lamp without a filament, or one in which as in the ordinary "arc," some substance such as carbon, would not be actually consumed. In a paper read before the American Institute of Electrical Engineers in March, 1920, Mr. Moore made a very interesting survey not only of his own remarkable work, but of the developments in this whole subject up to date.

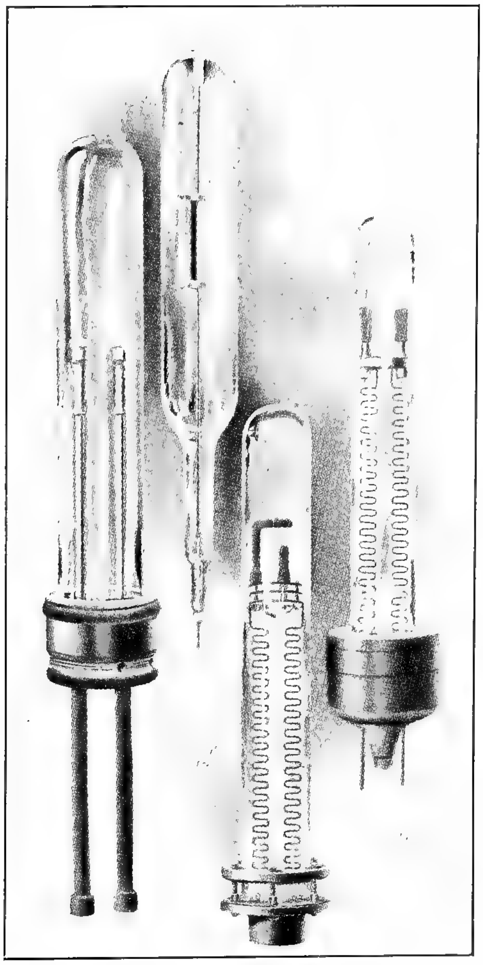
Electricity, as Mr. Moore then pointed out, can be used to agitate into light either solids or liquids or gases. The light of the typical incandescent lamp is due to solids heated electrically; and when electrical energy is conducted by a gas, under suitable conditions, light again results. A separate chapter dealing with the use of mercury vaporized is embraced in the splendid achievements noted elsewhere of Dr. Peter Cooper Hewitt. The first artificial electric light, as distinguished from lightning and the aurora, may be said to have been produced with the revolving glass sphere of Hawksbee in 1750. A hundred years later, Geissler first operated his celebrated little tubes with an induction coil. In 1879, Crookes modified such tubes in various ways. About 1891, Nikola Tesla delivered his famous lectures on "High Voltage and High Frequency" and showed many novel and surpassingly beautiful lighting and luminous effects. In 1893, Mr. Moore, whose attention had been arrested by the phenomenon of the blackening of incandescent lamp bulbs, pondered the problems involved in constructing a filamentless lamp, at which time, he said: "I meant a bulb form of lamp, the light source of which was to be, not an incandescent solid conductor, but an enclosed gas or vapor electrically agitated by the low tension circuits in common use."

Thereafter for many years down to the present time, Mr. Moore experimented in every direction and ceaselessly, trying in his onward path all the known gases; but at first without any very startling result. The induction coil and the Moore vacuum

vibrator were successively employed. In 1898, the discovery of neon was announced, and noting its exceptional luminous efficiency making it unique among light sources, and Mr. Moore immediately proposed its use for lighting purposes. "Its luminous spectrum is," he remarks, "almost ideally located to affect the eye in a maximum manner. It is a splendid example of selective emission or radiation that eliminates the long and therefore inefficient waves."

Going back in the story, as to the bulb or tube itself, it may be noted that in 1895, the vacuum vibrator on direct current circuits caused the bulb lamps to be filled with quite effective light from the negative glow, and this was used in a commercial way for advertising purposes. In 1896, Mr. Moore created a genuine sensation with his seven foot tubes, with external electrodes, and the meeting hall of the A. I. E. E in New York City was thus lighted. The Moore vacuum rotator next succeeded the vibrator in 1897, and the historical Moore chapel in the Madison Square Garden exhibition of the National Electric Light Association attracted universal attention. The arches or spans were curved tubes, so that the lighting became architectural. The first instantaneous electrical portrait, that of Hon. Chauncey M. Depew, was there taken with a 5-foot tube. The technical journals of the day abound in interesting descriptions and illustrations of the Moore installations of the kind above noted.

In 1899, vacuum breaks were abandoned in favor of resonance coils and a low frequency generator, to be succeeded by high frequency generators; and the Moore laboratory was thus lighted. In 1902, the first "long tubes" of Mr. Moore were brought out, about 100 feet in length —and in 1903 these were improved by the use of internal electrodes. A little later the first rotary high vacuum oil pump was developed for the exhaustion of the long tubes built on the spot. A24-foot CO_2 tube with a carbon cathode was brought out, starting with higher potential on 220 volts D. C., with a resultant highly efficient light; and other such tubes and lamps had metallic cathodes buried in lime, etc. It was noted that when operated on alternating current, rectification took place. Up to 1904–5, it was the practice to use a special generator with each "long tube" installation, but now brilliant illumination was obtained, with the use of nitrogen gas, from street circuit current. Special electrodes were also constructed with auxiliary circuits, similar to those used later in rectifiers, pliatrons and X-ray tubes. The life of the long tubes was increased—1906-1909—to 10,000 hours by the invention of the electromagnetic feed valve, and over four miles of light-giving tube was now in commercial operation. Such installations as the Madison Square Garden lobby and the New York Post Office may be noted as of this period and Mr. Moore said: "No light source known today equals in

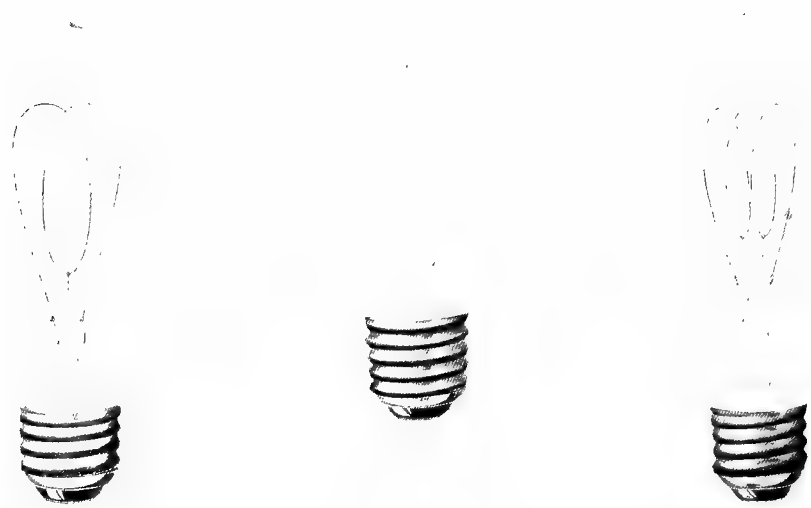


First Forms of Platinum Filament Lamps

efficiency a neon tube 1¾ inches diameter and 200 feet long. . . . Fundamentally, the first cost of a long tube system is less than that of a complete incandescent lamp system and its life is longer, with a resulting lower maintenance cost. It is simpler." During 1910-11, the long tubes disposed in the form of portable artificial daylight windows, made their appearance and still persist.

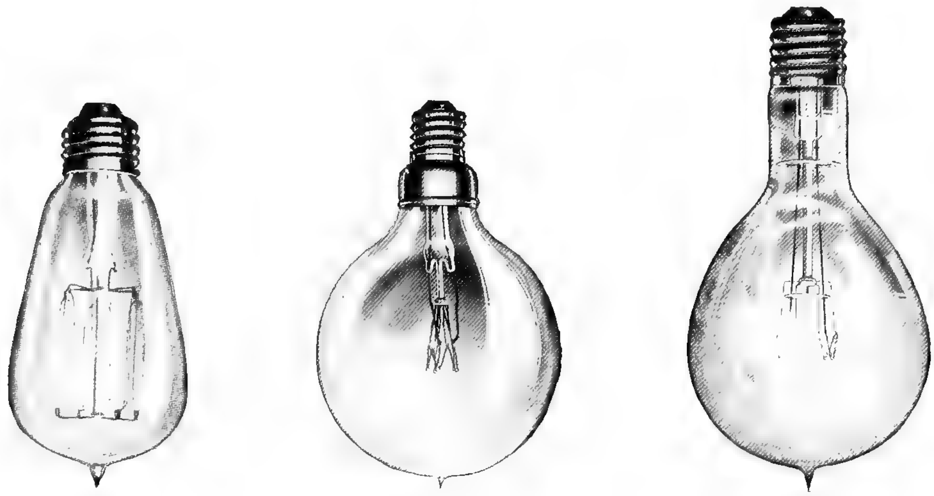
Between 1913-1915, various types of small tube lamps dependent on the new Moore principle of chemical gas feed were invented and put on the market for color matching purposes, and simple neon tubes operable from transformers were brought out in several varieties. Some of these consume 13 watts; have ordinary screw bases, and have been run over 4,000 hours. In the fall of 1916, the first portable commercial neon tube outfit of high intensity and efficiency, operated from a step-up 60-cycle transformer, made its appearance, in the form of a hairpin, having a total gas column length of 101 feet at ⅞-inch diameter, and a specific efficiency of .74 watt per spherical candle-power. Other such lamps, both A. C. and D. C. have been made, with their incidental methods of operation.

At the A. I. E. E. meeting in the spring of 1920, it was the type of lamp with cold electrodes, designed to start and operate without using high potential to which Mr. Moore directed special attention, "by no means fully developed, but fulfilling the original conception of a gaseous conductor lamp, without any auxiliaries for low potential circuits." A novel lamp shown then resembles an incandescent lamp outward form, and "perhaps is far more simple, yet it is not an incandescent lamp." Four electrodes made of aluminum each 6 inches long ⅝ inch wide and 1/16 inch thick are mounted in a 3-inch straight sided bulb without a common center. A glass hub provided with radial arms of glass support the electrodes, which have holes in them through which the arms extend. The effect of a solid radiator is approached by radiators made of very small meshed netting. In this lamp the characteristic crimson of neon has been displaced by a uniform mass of soft yellow light that somewhat resembles the color of a high-class oil lamp. Since the light is



Standard Types of Edison Carbon Filament Lamps, 1900-1

entirely due to negative glow, cathodic disintegration of the electrodes is one of the problems in connection with this type of lamp, but it is practically nil when the cathode fall equals its minimum value. The bulb blackening is far less with aluminum radiators than tungsten, nickel, copper, etc. Iron radiators, as well as various forms associated with fluorescent coatings offer promise.



Drawn Wire Tungsten of 1911 — Mazda C of 1913 — Recent High Wattage Mazda C

Various Types of Later Lamps

The lamp is designed for use on A. C. circuits at 220 volts, using 11 amperes and 21 watts, of which amount 3.6 watts at 33 volts is used in an ohmic resistance about 1 inch long placed in the skirt of the lamp base. The finished lamps will probably require no series resistance. Scores of modifications and varying designs have suggested themselves, adjusted to A. C. or C. D. conditions.

CHAPTER III

THE STORY OF THE ELECTRIC PASSENGER AUTOMOBILE AND THE ELECTRIC TRUCK

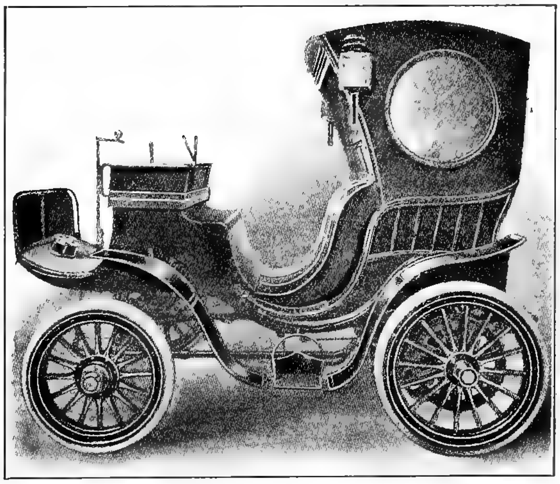
THE first self-contained and self-propelled electric vehicles go back to a very remote period. As early as 1835, an ingenious Vermont blacksmith, Thomas Davenport, who had already made an electric motor, applied the new power and principle to transportation, showing small model cars on a miniature track.* In 1851, Prof. C. G. Page put in operation an electric locomotive, on the railroad track between Washington and Bladensburg. It carried its own primary batteries, and therefore although running on rails was emphatically as self-propelled as any modern automobile. It made a speed up to nineteen miles an hour, but difficulties with the primary cells proved insuperable. It is also a matter of record that in Europe as far back as 1835, Stratingh and Becker, of Groningen, Holland, and Botto, of Turin, Italy, constructed crude electric carriages; while in 1838-9, Davidson, a Scotchman, built an electric car weighing not less than five tons, with which he obtained a speed of four miles an hour. Similar work was done by Prof. Moses G. Farmer in 1847, whose little car still survives, and by Thomas Hall, who showed a model electric car or locomotive at the Charitable Mechanics' Fair in Boston, in 1851. Thereafter for some years, down to the development of the modern street car and electric locomotive for regular railroad systems, the work on the self-contained, self-propelled vehicle for highway use languished. It was not until the storage battery became well developed and relatively perfected that the modern era of the electric vehicle began, dating roughly from 1887-8. Very soon after the invention of the Faure storage battery in France, a French company not only applied these cells to street car operation, but equipped a tricycle, which is said to have given good results. Professors Ayrton and Perry, well-known English scientific pioneers, made an electric tricycle in 1892. It carried a small motor under the seat, geared to a spur wheel on one of the rear wheels; while a suspended platform carried some cells of storage battery; the motor part weighing about 45 pounds and the battery 100. In 1886, Radcliffe Ward began electric carriage experiments in England, and in 1887, he had a storage battery cab running around Brighton. It carried 28 cells, weighed about 25 cwts. all told, and made a speed of 7 to 8 miles an hour. Encouraged by its success, Mr. Ward put an electric omnibus on the streets of London town in 1888. It covered no fewer than 5,000 miles, and made a speed of about 7 miles an hour. About the same time, 1887-8, Magnus Volk ran an electric dogcart successfully on the streets of Brighton, driven by 16 small accumulators, and attaining a

* See "An Appreciation of Thomas Davenport," by T. C. Martin. An address before the Vermont Electrical Association, Forestdale, Brandon, Vt., September 28, 1910, when a bronze tablet in memory of Davenport was dedicated.

speed of 9 miles. In 1888, he built another electric dogcart for the Sultan of Turkey, with a battery of 24 cells, weighing 7 cwts. The total weight was 11 cwts. The motor of 1 h.p. was placed under the body, and drove direct on the rear wheels by chains. In France, a very satisfactory electric carriage was built by Pouchain in 1893—a six-seated phæton on four wheels, with a storage battery of composite type, of 70 hours' ampere capacity, and a Rechniewski motor of 3.5 kw., driving at a normal speed of 1650 r.p.m. on the rear axle by intermediate shaft and chain gearing. Variation in speed was effected by battery grouping. The motor weighed 240 pounds, the battery 1,110 pounds, and the vehicle complete 1.25 tons.

Other French pioneers of this period were Sarcia and Monsette; while in 1894, Blumfield and Garrard brought out a four-wheel vehicle on bicycle lines, with pneumatic tires, and a motor running at constant speed with a variable speed gear. Jeanteud also built electrics at this time, and one of them, in 1895, took part in the famous Paris-Bordeaux races, covering some 600 kilometers (375 miles) by means of frequent recharging en route. In London, in 1894, Bersey did some quite prophetic work by building a neat electric parcels van, which ran around the streets for several months. The Pioneer Electrical Car Company and the Electrical Road and Street Car Company also put some electrical vans into operation. The locomotive Acts of England stood in the way, however, of the free use of any form of motor vehicle at that time; but in 1896, the Light Locomotives Act was passed, removing the shackles from the British automobile industry, and the Vaughan-Sherrin electric was one of those to celebrate the event in the memorable Brighton run; and next year electric cabs were placed on the streets of the British metropolis. With that, the first English and French pioneer period, historically may be said to have closed.

In America, during the summer of 1888, a small, one-passenger electric runabout was exhibited on the streets of Boston, Mass., by Mr. P. W. Pratt, and attracted some attention; but it was a purely sporadic attempt, of which nothing came, although the time was certainly ripe for advances. In the same year, Fred M. Kimball, of Boston, is said to have built a small electric car of crude design, but "which ran." It is also a matter of record that in 1890, Messrs. Perret and Barrett (Frank A. Perret is the well-known motor designer, and later seismologist in Italy) built in Brooklyn, N. Y., a wagon which they propelled by electricity. The coach-work was done by John Curley, and the wagon was placed on exhibition in the Curley store window on Clinton Street,

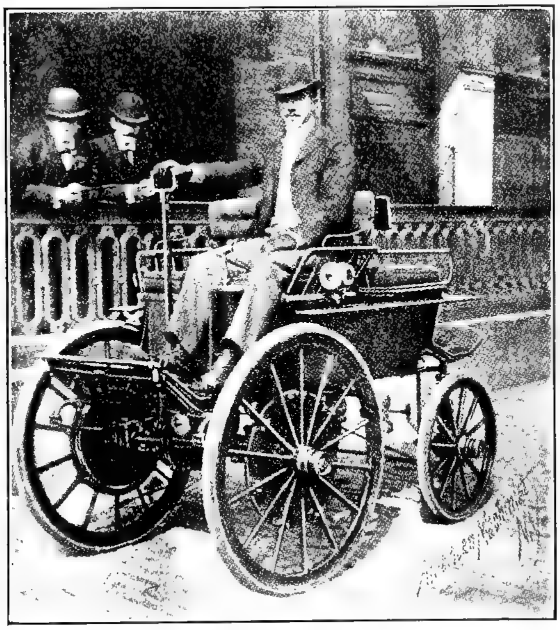


London Electric Cabriolet

New York City. Practically no figures are available, however, as to serious or sustained road performance. It was some four years before another landmark was set up in American electric vehicle development, when Mr. Fiske Warren, a prominent Bostonian, gave an order to the Holtzer-Cabot Electric Company, of Brookline, Mass., to build an electric "brake," to be capable of carrying eight passengers. This was duly produced, as the concern were capable manufacturers, and the storage battery, long before experimented with and developed by Dr. Charles F. Brush, of Cleveland, was now available also in the United States, in standard commercial form. The Holtzer-Cabot machine was operated over the crooked and rather steep streets of Boston, at an average speed of 8 miles an

hour, making 40 to 50 miles on one charge of the battery, and attaining a speed of 16 miles an hour.

The next real steps of any importance bring us up to 1894-5, when Messrs. P. G. Salom and H. G. Morris, in Philadelphia, and A. L. Riker, in Brooklyn, N. Y., brought out vehicles of an essentially practical character. The Morris-Salom vehicle was put in operation August, 1894. It had a 3-h.p. motor, weighing 300 pounds, and



Morris and Salom Electrobat

1,600 pounds of storage battery, making about 50 miles on one charge, and reaching a maximum speed of 15 miles per hour. The motor could be worked up to 9 h.p. for a short time, and was connected through a pinion on the end of the motor shaft to a countershaft having a balance gear to enable the wheels to move independently in turning curves. At the ends of this countershaft were pinions meshing into large gears attached to the rear wheels of the wagon. The wheels were ordinary, heavy wagon type with iron tires. The front of the wagon rested on a fifth wheel of 30-inch diameter, attached by an iron frame to the rear axle. The lower half, and revolving, part of the fifth wheel rested on the springs between it and the front axle. It turned on hardened ball bearings, being moved by the hand-wheel on the top of the shaft, thus securing facility in steering and ample power. The controller regulating the current was placed in front of the footboard and operated by shaft and crank immediately below the steering wheel. The vehicle had a seating capacity of six persons. This was followed up by the Electro-Cab No. 2, which was prize winner in the *Times-Herald* competition in Chicago, November 28, 1895, when the Sturges electric also ran, and the Duryea gasoline car, one of the earliest of its kind. The No. 2, designed to carry four passengers, weighed with the batteries only 1,650 pounds. No mechanism was in sight except the steering lever and gear. The Chicago race was literally run in a blizzard, "with the cars barely able to crawl through the drifts to the finish line," but the race made a great sensation. The cells were those of the Electric Storage Battery Company, of Philadelphia (ever since a leading type throughout all the growth of the industry), and consisted of four sets of 12 cells each, 50-ampere hours per cell. The carriage could make up to 30 miles an hour, for a short time, and a maximum of 20 miles on good roads. The batteries were so placed in the car that they could be exchanged in less than two minutes. In 1896, the No. 2 made 5 miles in 11 minutes, or nearly 30 miles an hour, on a one-mile course at the Rhode Island Fair Grounds, Providence, R. I., while the gasoline cars made at best only 15 to 20 miles an hour.

In a loft in Brooklyn, N. Y., the experimental shop of Mr. A. L. Riker, the first four-wheeled electric machine was built in 1894-5. This young engineer was already a pioneer in the electric motor field, giving evidence of unusual skill as an inventor, and being fortunate in having command of useful financial resources of his own, with which he did not hesitate to back up his ideas and opinions. This first automobile production of the earliest Riker Electric Company was made up, according to the testimony of Mr. A. H. Whiting, who assisted Mr. Riker in all this work, of a pair of Remington bicycles with an electric motor slung between them.

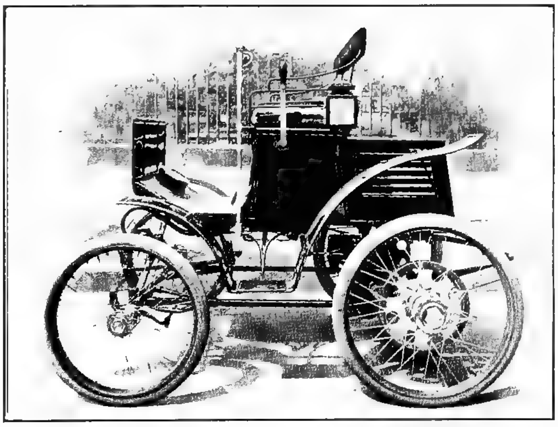
"It made a certain appeal to us because it would run. Our first real machine, produced in 1896, had a tubular frame and was one of the wonders of the day. It won the first actual track race ever held in America, at Narragansett Park, Providence. The race was a three-heat affair—a heat of five miles a day for three days—on a mile track. Seven cars took part, the Riker, which I drove; an Electrocab, built by Morris & Salom, and five Duryea gas cars. The Riker won the first day, was beaten by the Electrocab in the second heat, and captured the third and the race. The gasoline cars had no chance."

This Riker machine was equipped with two 4-h.p. motors, and weighed, with batteries, 1,800 pounds, making up to 27 miles an hour in the fastest heat. Then came similar contests at Guttenberg, N. J., Brookline, Mass., and Newport, R. I., in which the electrics continued to give a good account of themselves.

Probably the first American road race took place in 1898, over a 50-mile course on Long Island, from Springfield to Babylon and return. The prize was a silver cup. For this, Mr. Riker built a "piano box" type of electric car, winning easily. The second to finish was a Locomobile steam car, 19 minutes behind. The average speed of the Riker was 25 miles an hour. It is a curious coincidence that a few years later, Mr. Riker again did some splendid work in the pioneer gasoline field by perfecting and introducing the well known Locomobile cars of today. In 1899, Fournier brought from France a very fast Mors gasoline racer, and aiming at a mile a minute as a wonderful goal. The enthusiasts of that time organized a series of speed contests on the Coney Island Boulevard. The French machine was equal to the task, and in the electric class the Riker made a speed of 1.03 for the mile—a record which stood for three years until it was beaten at Ormond Beach, Fla., when that quite definite chapter of history may be said to close, so far as it is worth recording. "The subsequent proceedings" in the racing field, interested the electricians no more in the United States.

Returning to Europe for a brief glimpse, and resuming at the point where that part of the narrative was interrupted, it may be noted that the Jenatzy car and delivery wagon was brought to notice in 1897, and that two years later, Jenatzy won the kilometer record in France with his torpedo-shaped electric, oddly named the "Jamais Contente" ("Never Satisfied").

The De Dion-Bouton interests brought out a light electric in 1901, with 44 cells of 200 ampere hours capacity. The gasoline-electric car made its appearance in France as early as 1899, and in 1902, an alcohol-electric was entered by Krieger in French tests. It weighed 2,910 pounds,

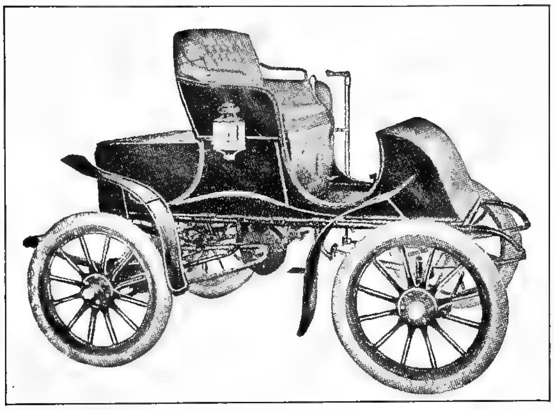


Early Riker Runabout

had a 44-cell battery of 8,882 pounds, and made a speed of 9.32 miles an hour. In 1901, the Opperman Company, of Germany, placed an electric van in the service of the British Post Office in London, and the British Electromobile Company developed a car in 1902; but soon after, the American machine invaded the English market, and the lines of development merged or were confused. As Mr. P. D. Wagoner has said: "Europe had a very important part, not only in the development of storage batteries, but of electric vehicles as well. But all this development practically stopped so far as the electric vehicle is concerned about 1903. The progress made from 1903 to 1909 appears to have been spasmodic in character and wanting in cohesion."

During 1897, Mr. Riker brought out a very interesting and successful type of electric "stanhope"—a four-wheel, four-

seated conveyance of dogcart type, seats back to back across the carriage, and with low dashboard, on which was mounted a new type of Weston meter, reading both volts and amperes, easily seen from his high seat by the driver. The carriage was equipped also with electric sidelights, headlight and bell. The weight was 1,800 pounds complete. The wheels were 32 inches front and 36 inches rear, with 3-inch pneumatic tires. One Riker motor of 2 k.w. was carried, driving on the rear axle, at 1,000 revolutions per minute, making single reduction at a ratio of 9 to 1.



Early Studebaker Runabout

The axle was double, the motor being fixed upon the outer stationary axle or sleeve; motor and gear being encased, water and dust proof. The motor weighed 142 pounds. The storage batteries were of zinc-lead type, 36 cells, weighing 700 pounds, giving 150 ampere hours at a 10-hour rate of discharge, and 120 at a 4-hour rate. Steering was done by a vertical handle, applied by toggle joints to the front axle. The controller lever was on the left-hand side of the carriage; it worked backward and forward, the direction of its travel corresponding with that of the vehicle. A speed of 25 miles an hour could be obtained.

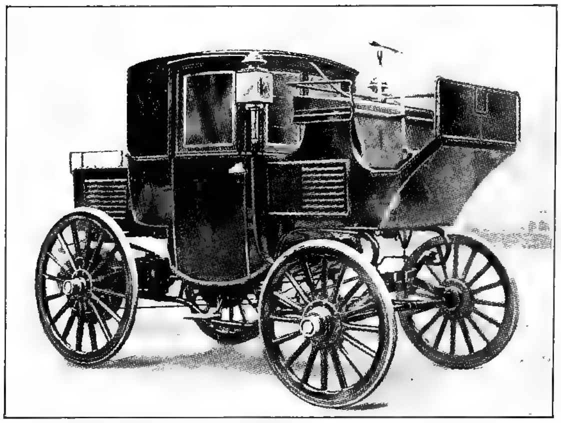
In the same year, 1897, after experiments extending over two years, the first motor vehicle of the celebrated Pope Manufacturing Company was publicly tried out at Hartford, Conn. It was a two-seated phaeton, driven by a 2-h.p. Eddy motor, working directly on the axle; had a powerful foot brake, and developed a speed of 12½ miles an hour. It was considered quite an advance at the time. The first electric car of the Waverley type was built by the Indiana Bicycle Company at Indianapolis, also in 1897. It was of the "stanhope" design, with 36-inch wheels and single-tube tires, large herring-bone gears, and a Porter storage battery and 4-pole motor. It is said that of this type or cars very closely resembling it, no fewer than about 200 were built; while some 50 of the dos-a-dos type with wire wheels, and seats arranged like those of a jaunting car, were shipped to various parts of the world.

In 1897, Morris & Salom exploited various designs of electric broughams, hansoms and runabouts in New York City under the name of the Electric Carriage and Wagon Company, the successors to which were the Electric Vehicle Company and the New York Transportation Company, which through a long series of years developed the electric vehicle and an electric taxicab service, with Mr. G. Herbert Condict, as chief engineer; while a number of electric stages were also put in operation on the Fifth Avenue route, giving very general satisfaction; but in the end being dropped from service because they could not be made profitable enough to compete on equal terms with the swelling numbers of gasoline competitors.

Returning to the Pope vehicles of the Columbia type, it may be noted that some interesting and quite successful work was done by Messrs. H. P. Maxim and Hayden H. Eames, contributing in an important degree to the early development of the art. Their Mark I electric stanhope of 1895-6 used a single motor on a hollow shaft, through which the rear axle passed, driving on the rear wheels by a train of gears starting with a pinion on the armature sleeve, which in turn drove a small countershaft back to the rear axle differential gearing. With this gear, however, the motor could not be removed without disassembling the entire rear axle and transmission. Mark IV, a surrey, built in the same year, had a double motor drive, the motors being supported on a frame of steel tubing mounted in the plane of the axle, using single reduction gear. All the

motors of the Columbia vehicles were thus mounted on or supported by the rear axle, which, of course, had its effect on motor design. The weight of the motors was gradually increased, which led to the production of heavy, low-speed motors, usually two, mounted on the rear axle by arms cast directly on the frame and driving by single reduction spur gears. An early Columbia type was the Mark VI dos-a-dos, in which an improvement was introduced by moving the motor forward of the axle, attaching to the latter by short arms. The countershaft passed through the motor as before, but the differential gearing was mounted on the armature quill. This gave a single instead of double reduction, with a small pinion on each end of the countershaft, engaging with a large internal gear, attached to the hub of each driving wheel. Some 25 of these were built, with wire driving wheels made up on sleeve hubs attached to the main hubs by bolts. Mr. H. S. Baldwin, in Columbia employ, invented the removable wire wheel early in 1898, it thus being of American origin instead of a foreign idea, as generally supposed. Early cars were built having the motor supported on the car body, but it was not until 1903 that the first Columbia of this type was placed on the market. When it is noted that the Columbia makes ran up to Marks XVI and XVII, or even higher in the series, it will be realized that only a general characterization can be given here of a few of these earlier types, constituting a notable and important chapter of the development as a whole.

As to the motors used in the earlier electrics of this time, Mr. Baldwin makes an interesting summary, as follows: "Several of the early motors, particularly the Eddy, Riker and Woods design, were of 'consequent pole' design; that is, only two poles carried field coils, the other two being spots or pads bored out to the correct diameter. This gave an elongated frame, which was considered desirable on account of its small appearance, the motors being supported by arms attached to the rear axle of the car. It was soon found, however, that better mechanical and electrical results could be obtained by adopting a 4-pole motor of cylindrical design, mounted in the same way. For a number of years this type was standard for cars that were built in large numbers. There were usually two motors, one for each driving wheel; the gearing being usually arranged for single reduction. Motors of this class were fairly light at the beginning, but gradually increased in weight from less than 200 pounds to more than 300 pounds each. Two hundred pounds of motors were too high a price for the omission of the differential gear and countershaft, and although hundreds of cars so motored were built and successfully used, the practice was finally abandoned in favor of supporting the motor on the chassis or body." Mr. Baldwin makes note also of motors built so as to be mounted directly on the drivers, and of the gearless wheel motors.

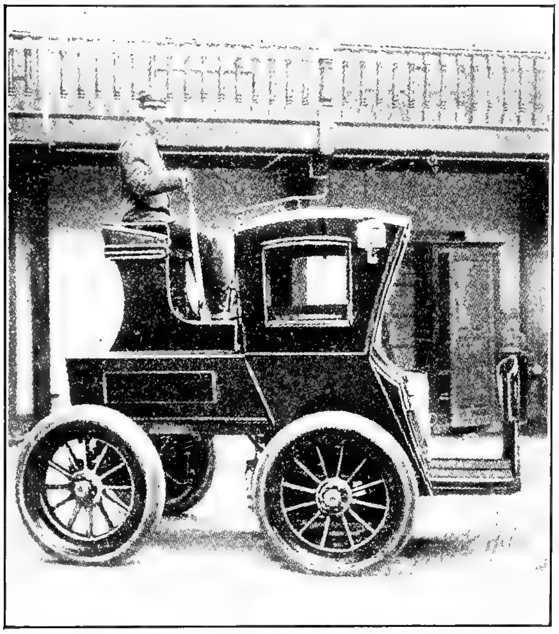


Early Riker Brougham

AUTOMOBILE SHOWS

In the early days of electric vehicle development, coinciding with the close of the last century, began the long series of automobile shows, which continue with growing magnitude down to the present year of grace. The first of such American shows, devoted to electric, at which time they had hardly any real competitors from the steam or gasoline fields, were given in connection with the electrical exhibitions held in Madison Square Garden, New York City, 1898 and 1899, at which time early types of the Columbia, Riker, Waverley, Woods, and Burrows were put

on view. The first automobile parade in New York City was held also in 1899, November 4, at which time, it is interesting to note, there were 38 cars in line, moving up Fifth Avenue, of which no fewer than 22 were electrics,—only 8 being gasoline and 8 steam. Closely following this came on February 10, an address by Mr. Riker before the newly-formed Automobile Club of America, which then had modest, small rooms at the Waldorf-Astoria Hotel. The address serves well as a summing up of the conditions surrounding the electric vehicle at the outset of the Twentieth Century. Mr. Riker said there were then on the market, electrics capable of making 50 to 75 miles on one charge of the battery, while he had had a report from France of a carriage that had made 108 miles on a single charge, and weighed complete only 2,200 pounds. As to cost of operation he quoted the record of a vehicle that had been running in the U. S. A. since 1897, covering over 20,000 miles. The cost of battery maintenance had been three-fourths of a cent per mile, or $150. The current, supplied at a charge of 10 cents per horsepower hour, had cost 1¾ cents per mile, or a total of 2½ cents per mile. He opined that such cost would be easily brought down to 1½ cents, and believed also in the early appearance of a battery to carry two passengers 50 miles on one charge in a vehicle not to exceed 1,000 pounds.



New York Hansom with Wooden Wheels, 1898

It would doubtless be interesting, but is not possible here, to review in detail the incidents from the beginning of the century up to the time of the Great War in the development of the electric vehicle. The fact is one of general knowledge that through that period of 15 years the gasoline car came most decidedly into its own, with electricity dropping to the second place and steam to the third, so far as general introduction and commercial utilization are concerned. One of the very interesting circumstances surrounding this evolution is the fact that so many men setting their mark on the gasoline vehicle art were graduates from the school of electricity. Mr. Riker has already been referred to in this respect, but it is not so well known that Mr. Henry Ford, in the humble days when he was trying to lick his first crude gasoline car into shape was a machinist in the service of the Detroit Edison Company, whose pioneer central station gave frequent evidence of his skill and ability, although no one watching his struggles to make the car run had the power of prophecy so developed as to predict his spectacular and unequalled career as the "father of the flivver." Nor must it be forgotten that Mr. Ford still has a promise to carry out in giving the world an electrical equivalent to the cheap and ubiquitous "tin Lizzie." In the meantime, it is a mighty poor gasoline car that has not got a complete electrical equipment for everything but propulsion. The year 1911 saw the first automobile regularly furnished with electric starting and lighting plant or equipment, evolution of the primitive use of dry battery and magneto; and every season now witnesses some refinement or addition to the uses of electricity on the modern gasoline car. It all points one way.

Before presenting here final remarks on and pictures of the electric automobile for passenger service as it stands to-day, a few pages must be devoted to the electric truck, which has enjoyed an evolution all

its own and has proved a formidable competitor for the gas truck, meeting it on superior terms in many fields of use and economy.

EVOLUTION OF THE ELECTRIC TRUCK

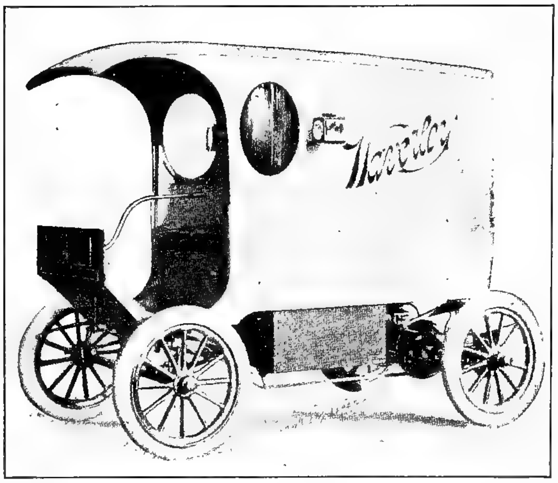
Incidental reference has necessarily been made in the preceding section of this chapter to the commercial and industrial types of the electric vehicle, in the earlier stages of their evolution. It is hardly stating it too strongly to say that the electric business vehicle has shown itself much more able to hold its own with the gasoline motor truck than has the electric passenger vehicle with the pleasure type of gasoline car. While until recently, the passenger electric seemed still to be under the depression that had endured for well nigh a decade, the electric commercial and industrials have steadily forged ahead, and must be conceded even by their opponents to constitute very successfully the bulk of development in their general class of transportation.

The first practical commercial American electric vehicle is credited to Riker, about 1897, with many successors from the same hands. In 1901, Tiffany & Company, the celebrated jewelers of New York City, had three 2,000-pound delivery wagons, which with nine others of General Vehicle make, were noted as still in use in 1914. At that time, the same firm had 22 electrics, 19 of which were over 9 years old. It was said at that time also: "There are unquestionably fully 70 commercial electrics in service that are over 10 years old, and hundreds that are over seven years old." In 1914, the Committee on Electric Vehicles of the Ohio Electric Light Association gave authoritatively some very interesting figures as to the commercial and other vehicle development at that time in the following cities:

City	Passenger	Commercial	Total
New York	498	1,700	2,198
Chicago	2,500	636	3,136
Washington	775	270	1,045
Denver	850	65	915
Hartford	300	50	350
Baltimore	19	89	108

From this it would appear that as far back as eight years ago, these six cities had no fewer than 2,810 commercial vehicles; while additional figures were given as follows: Cincinnati, 65 trucks; Cleveland, 95; Columbus, 8; Toledo, 16; Dayton, 25; Youngstown, 7; Akron, 6; and Bucyrus, 1; or 223 more in 8 Ohio cities. From this, the general status throughout the country may be readily inferred.

With the outbreak of the Great War, activity in this field, as in many others, was

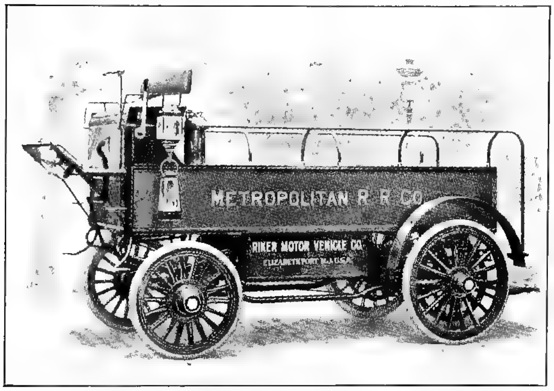


Waverley Delivery Wagon, Early Type

interrupted or completely suspended, but it was estimated at the end of 1916 that at least $36,000,000 was then invested in commercial vehicles in the U. S. A., many concerns and corporations operating large fleets of them, with every indication of satisfaction and success. Thanks to the return of peace, and to release from war activities and duties, many central stations have resumed their cultivation of this field. Two companies at least have put in operation a "battery exchange system" for commercial vehicles, and a very large number of central stations have made available charging facilities, and many private concerns have installed considerable charging plants of their own. Typical of what is being done with the electric truck may be mentioned the example of the American Railway Express, which operates at the time of writing 1,258 electric trucks, which require annually about 12,000,000 k.w. hours of electrical energy

for their storage batteries. A contemporaneous illustration of efficiency is afforded by one fleet of 83 trucks, of which 76 are electric. All of these trucks are operated over practically the same territory, and it is found that the total cost of operating the electrics is only two-thirds that of operating the gasoline trucks.

Moreover, the increasing cost of gasoline has come in to influence the situation and to control it as a vital factor in favor of the electric truck. An interesting chart was compiled not long ago by one of the largest operators in America of both gaso-



Early Riker Electric Emergency Wagon

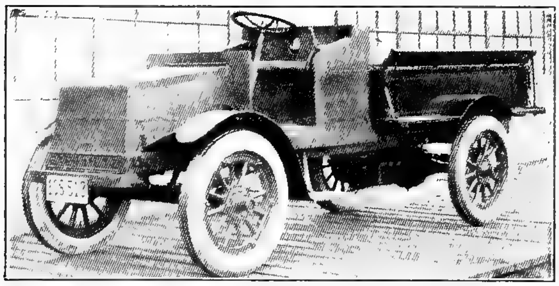
line and electric trucks, covering a period from July, 1915, up to and including December, 1919. This chart shows that the cost per ton mile with the gasoline truck increased from 5.3 cents in 1915 to 6.75 cents in 1919; while the cost of the electric ton mile fell from 4.74 cents in 1915 to 4.17 in 1919. The average tons capacity for the gasoline equipment increased only from 3 to 3.27, while that of the electric increased from 1.6 to 2.7. All the trucks were operating under the same conditions in city delivery. The figures include all expenses except interest, depreciation, insurance and drivers' wages. It is significant that the price of gasoline on contract was 8½ cents per gallon in 1915, and was 22 cents in December, 1919. It has not since receded, but risen still higher. There was an increase of 150 per cent. in four years. But during the same period the cost of electric current fell from 1.88 per k.w. hour to 1.65. It is also stated on the returns of large users of both classes of vehicles that a 5-ton gasoline truck operating an average of 40 miles a day costs approximately $5 to $10 per day more than a 5-ton electric doing the same work. There can be but one result and finale with such evidence before those who are occupied with the various problems of trucking and vehicular transportation throughout the country.

Reference is made just above to the "battery exchange" system or kindred central station service. In 1910, the Hartford, Conn., Electric Light Company took a hand itself in the sale of commercial electric vehicles, and furnished free garage and charging current for six months on all new cars. In 1911, it developed a battery service, which was steadily pushed until 1914, and which has again been pushed since the Great Peace. From June, 1912, to January, 1919, more than 3,000,000 miles of trucking was done in Hartford through the instrumentality of the "battery service" system with a total revenue therefrom to the company of $176,547. A large part of the charging was done at night, so that the added investment required in generating, transmission and distributing equipment was practically negligible. Edison storage batteries were used and stood up splendidly under the hard service exacted.

In 1918, the Commonwealth Edison Company of Chicago started an interesting electric truck service in which all transportation costs were guaranteed except the first cost of the trucks, insurance, and the wages of the drivers. The cost of the service is a flat rate payable monthly, dependent on the size and equipment of the truck, whether lead or Edison nickel-iron battery; and based directly on the average service rendered. The included items are garaging or storage, cleaning and care, the supply of electrical energy, and the maintenance of the wearing parts of the vehicle, lubrication, inspection, and even painting of the body at specified intervals. The execution of the service began with a new garage building at Jackson Boulevard and Morgan Street, Chicago, known as Service Station No. 1, with a capacity for 100 trucks or delivery wagons.

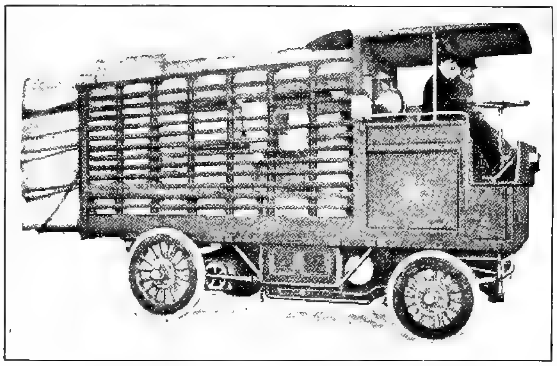
THE ELECTRIC VEHICLE ASSOCIATION

During the "renaissance" period of the electric vehicle in America, at the close of the first decade of the century, a number of the leading spirits in the industry were impelled by their enthusiasm to organize after the fashion of the times a separate organization for the promotion of the industry. Hence in 1911, the Electric Vehicle Association of America was formed, and it continued in autonomous existence until 1917, when it was merged in and absorbed by the National Electric Light Association. Its presidents were as follows: 1911-13, W. H. Blood; 1913-14, Arthur Williams; 1914-15, Frank W. Smith; 1915-16, John F. Gilchrist; 1916-17, Walter H. Johnson. Under the presidency of the last-named, the Association became the Electric Vehicle Section of the N. E. L. A., still enjoying the efficient services of Mr. Jackson A. Marshall as secretary. It is now been continued as a part of the Commercial Section of the N. E. L. A., through which all the



Steinmetz Electric Truck of 1922

proper necessary functions are discharged; although some of the geographical divisions of the N. E. L. A. still maintain their Electric Vehicle Committees. Thus that of the New England Section, Mr. Day Baker, chairman, in a very interesting report under date of September, 1920, said: "One of the most convincing arguments in favor of the electric truck was its great and consistent performance during the tremendous fall of snow in the early months of this present year. Business



Early Fischer Heavy Electric-Gasoline Truck

houses which found their gasoline trucks almost helpless after a few days of the heavy snow service, were able to keep their electric trucks at work during the whole snow period.

"Practically every roll of paper used by the Boston daily newspapers is hauled by the electric trucks, and no edition was short of stock during the great snow period. A great fleet of electric coal trucks delivered coal, by the use of extra batteries and three shifts of drivers, continuously 24 hours a day, for forty days during all the deep snow weeks. The fleet of great cotton hauling trucks that ply between the wharves and the warehouses along the water front of Boston never lost a day during the past winter. Many more similar statements could be made showing the dependability of the electric truck, and all these facts have given the electric truck in Boston great prestige, and have made friends for this method of haulage."

CHAPTER IV

ELECTRICAL DEVELOPMENT AT SEA

THE use of electricity at sea was for many years practically confined to lighting and engine room signalling. One of its earliest American naval applications for power purposes was in the installation of small motors for ammunition hoists and for turning two of the turrets of the cruiser *Brooklyn,* which was launched in 1895; and equipments for similar purposes were installed in Europe almost contemporaneously with the *Brooklyn* experiment.

This was an opening wedge for experimental demonstration of the advantage of electrical operation of mechanical auxiliaries on board ship, encouraging the expansion of electrical applications to marine work. Quite a large advance in that direction was made in the equipment of the *Kearsarge* and *Kentucky,* battleships of the United States Navy, launched in 1898, in which extensive installations were made covering most of the mechanical operations of those famous vessels. Their electrical equipments so proved their value that they became standard for all the later battleships, besides many other devices for other auxiliary applications, until now the electrical plant of a modern steam-driven battleship is a large one, covering besides lighting installation, many kinds of signalling devices, and motor-driven auxiliaries in great variety. The United States Navy has largely pioneered the way in the volume and variety of its electrical applications, but the navies of the other great naval countries have not been slow to introduce innovations of their own, so that, except for its actual propulsive drive, practically every large mechanical operation of a modern battleship is electrically executed. Meanwhile the subject of electrical propulsion has come to the front as one of the most absorbing problems in the great competition, and here, too, America has taken the lead in a most progressive and bold initiative, with seven large battleships and five battle-cruisers of unprecedented size and capacity, all to be equipped with and propelled by electricity. Details of this are given later in the present chapter.

At one time it looked as though the electric boat would make a very large and distinct field for itself, but its vogue, as has been the case with the electric automobile—and to a much greater degree—has been lessened and interrupted by the tremendous development of the gasoline type of conveyance.

Electric launches, although not so frequent now as one would like to see them, have a long history. Prof. Jacobi, a distinguished physicist and electrician, residing at St. Petersburg, Russia, in 1838, made a striking demonstration of what could be accomplished with electrical energy and the electric motor as a means of propulsion.* Toward the expenses of the experiment, Emperor Nicholas con-

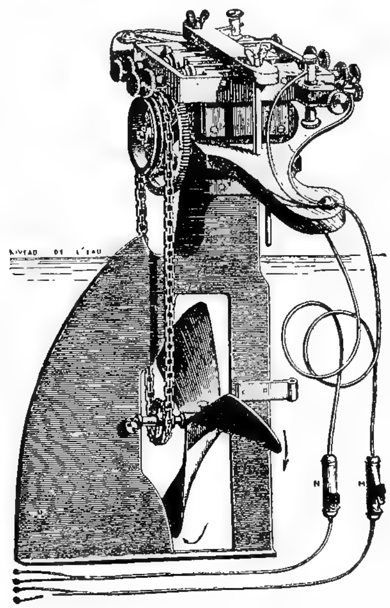
* For a very full account of early work of the kind and of that done up to the date of its publication see "Electrical Boats and Navigation," by T. C. Martin and J. Sachs, New York, 1894. This is the first American book on the subject.

tributed \$12,000. The Jacobi boat was propelled by primary batteries at a speed up to 3 miles an hour, Grove and Daniell cells being used and the little motor being geared to paddle wheels. The boat carried as many as 14 passengers, was 28 feet 7 inches long and had a draught of 2 feet 8 inches.

Nothing came of this or many later experiments with primary batteries, but in 1881 at the Paris Exposition an ingenious French inventor named Trouvé tried some Planté storage batteries, and managed to transport 4 or 5 passengers at a rate of about 3½ miles an hour. This was naturally followed up by the use of Faure (or pasted plate) storage cells; and much attention was directed to the successful work of Anthony Reckenzaun, a brilliant young Austrian engineer, who, in 1882, built and ran on the Thames the launch *Electricity* with 45 Faure (Sellon-Volckmar) secondary batteries. She was a boat of good size, being 25 feet long and 5 feet beam, with 1 foot 9 inches draught forward and 2 feet 6 inches aft. The batteries drove two Siemens motors operating singly or jointly a 22-inch propeller screw. The boat would carry 12 passengers and is said to have made as high a speed as 8 knots an hour against the swift Thames tide at London.

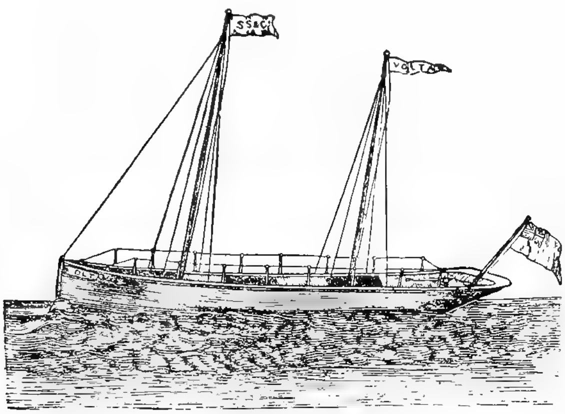
In 1883, the famous Yarrows firm of England operated at the Vienna Electrical Exposition a 46-foot launch carrying 50 passengers at 8 or 9 miles an hour; 70 accumulator cells driving a single motor, of which the armature shaft was extended as the spindle of the screw. Continuing this line of work, Mr. Reckenzaun again made history in 1887 by crossing the English Channel from Dover to Calais and back with his launch *Volta*. She was a boat 27 feet 6 inches long, 6 feet 10 inches beam and 3½ feet draught, with 61 storage cells under the floor, driving two Reckenzaun motors. The boat carried 7 passengers and made 12 miles an hour. The batteries were charged only at starting, and as she sped smoothly over a calm sea, one of the party captured with his hands a sleeping gannet afloat on the waves of the Channel.

Thereafter came many other similar and improving demonstrations. So far as known, the first storage battery boat put in commission in America was the *Magnet,* owned by Anthony Reckenzaun and his brother Frederick, built at Newark, N. J., in 1888. She was 28 ft. long, 6 feet beam, and 3 feet deep amidships with one Reckenzaun motor revolving a 2-bladed screw 18 inches in diameter, and with 56 storage cells made by the Electrical Accumulator Company. One charge of the battery was good for a 10 hours' run of 60 to 75 miles at 10 or 12 miles an hour. She had also a headlight with a 100 candle power lamp and seven 16 candle power incandescent lamps for interior lighting. She did service in New York waters until sent to California. In 1888 the present writer made a trip from New York to Newark and back in her, across New York Bay and the path of the ocean liners, the trip representing about 60 miles. As a result of this work, the Grand Duke Alexander of Russia when here ordered a similar launch sent to him at home, while one was obtained by the U. S. Navy Department and supplied by the Electric Launch Company for the U. S. Cruiser *New York,* to be used as a captain's gig.



"Trouve" Launch Motor and Screw, 1881

Such work led in a short time to the organization of fleets of electric launches all equipped with storage batteries; and pioneer effort in this direction may be said to have climaxed in the fleet furnished for the Columbian World's Fair at Chicago in 1893. A franchise was offered for operation over a three-mile course along the lagoons and canals of the exposition, connecting nearly all the important buildings

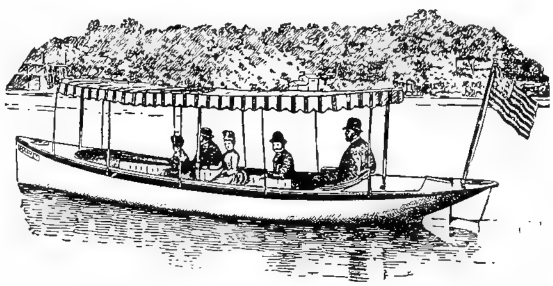


The *Volta* Electric Launch which crossed the English Channel in 1887

and communicating with Lake Michigan. Steam, gasoline and electric launches were entered and tested, and the contract was awarded to the Electric Launch & Navigation Company of New York, which equipped a fleet of 50 launches for the service, while the Exposition authorities installed four more boats for their own use. Each of these boats was 35 feet 10 inches over all in length, 31 feet 6 inches on the water line, 6 feet 2½ inches beam and 27 inches draught. It had a single motor, and 66 cells of battery of 150 ampere hours capacity, a run of 50 or 60 miles being made usually at 6 to 7 miles an hour. The greatest test of the launches was on the great Chicago Day, when no fewer than 622 trips, each of 3 miles, were made by the 50 boats. No fewer than 25,000 passengers were carried on that memorable day, all without accident; six of the boats averaged 50 miles each, and 20 averaged over 40 miles, carrying about 40 people each trip. That was indeed the swan song of the electric launch so far as present development is concerned, for the performance has never been surpassed, let alone equalled. During the Fair the fleet earned some $314,000 at 50 cents a trip, besides carrying a great many "dead heads," the fare being 50 cents for the three miles. After the Fair, the fleet was dispersed, and one boat was bought for Venice, whither it went to reappear in the waters so long associated with the song and oar of Adria's gondolier. From that day to this, work has never ceased in connection with such transportation, but the electric launch has still to come into its own.

THE ELECTRIC SUBMARINE

A separate chapter or category of electric boats is that which includes all modern submarines, as these are built and equipped so as to operate under water by means of storage batteries and electric motors, whatever may be the motive power employed for operation on the surface of the water. There is no need here to recapitulate the early history of submarine boats, or the work of such inventors of the primitive period as Fulton, Van Drebble or Bushnell; but note may be made of the fact that at the beginning of the modern period of electricity, the U. S. Navy in



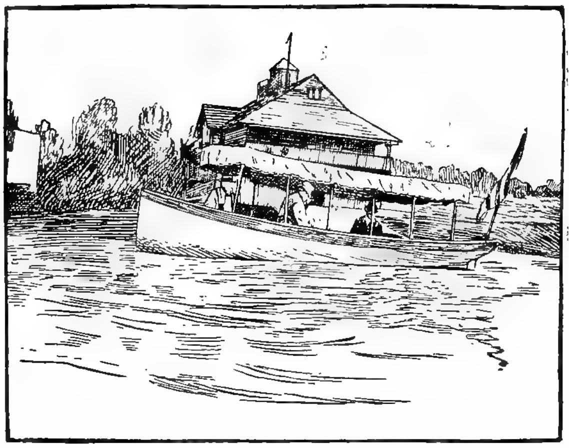
The Reckenzaun Launch *Magnet* on the Passaic River, N. J., 1888

1887 issued an historical circular on the subject setting forth the requirements to be fulfilled in a proposed steel submarine torpedo boat as an adjunct to the new American fleet. Here beginneth the story of the modern "diving boat" whose greatest achievement will doubtless long remain that of virtually blockading the British Isles as a murderous weapon of the Ger-

man Navy and by its indiscriminate attacks on the peaceful commerce of the world enlisting the United States in the great World War.

The first real submarine of the electric type was that evolved in 1888 by Lieut. Hovgaard of the Royal Danish Navy—a boat 122 feet long, 196 tons burden when submerged, with condensing engines of 600 pounds for ordinary surface operation, and 400 leadgrid storage cells driving an electric motor of 35 effective horsepower up to a speed when submerged of 6 miles an hour. The same year saw a boat built by Mr. J. F. Waddington of Seacombe, England. She was, however, only 37 feet over all, 6 feet diameter amidships, but was driven by compressed air and electricity. The electrical energy for operation was stored in 45 cells each of 660 ampere hours capacity, driving a motor of 7.96 effective horsepower which would thus propel the boat for 10 hours at a speed of 8 miles an hour. The same year saw also the submarine electric boat of Lieut. Peral of the Spanish Navy. She was 72 feet long, 9 feet 6 inches maximum diameter, 86 tons displacement, 2 feet 11 inches draught when operating on the surface, and was equipped with 613 cells of storage battery, driving propeller and pump motors. She had two screws for propulsion and two for submersion. Her nominal speed was 11 knots at the surface, and 10½ when submerged. Again, in 1888, which was a notable year above all others in this class of craft, the *Gymnote* was launched in France, her plans being accepted for the French Government by Admiral Aube. Shaped like a Whitehead "fish" torpedo, she was 50 feet long, 5 feet 11 inches greatest diameter, and 29.5 tons displacement. She carried about 10 tons of storage battery (564 cells) had a motor designed by Capt. Krebs, well known for his work in aerial navigation, and made a speed of 10 knots for 6 hours, being also steered and lighted by electricity. On one trial in 1888 she dived 23 feet and traveled 1000 feet under water at 4 knots an hour. In 1891 the French Minister of Marine reported that she had solved the problem of submarine navigation, and in 1893 she was still in operation, but was already giving way to better boats of the same type, such as the *Goubet,* operated at Cherbourg in 1889.

Returning to America, note should be made here that one of the earliest Yankee submarine electric boats was that of Mr. George C. Baker of Chicago, put into operation at Detroit in 1892. She was 40 feet long, 75 tons displacement, with a steam equipment for surface operation and to charge the 10 tons of 232 storage batteries which in turn supplied current for a 50 horsepower motor. The U. S. Navy Department report of 1892



The Primary Battery Launch *Electric* on the Potomac, 1888

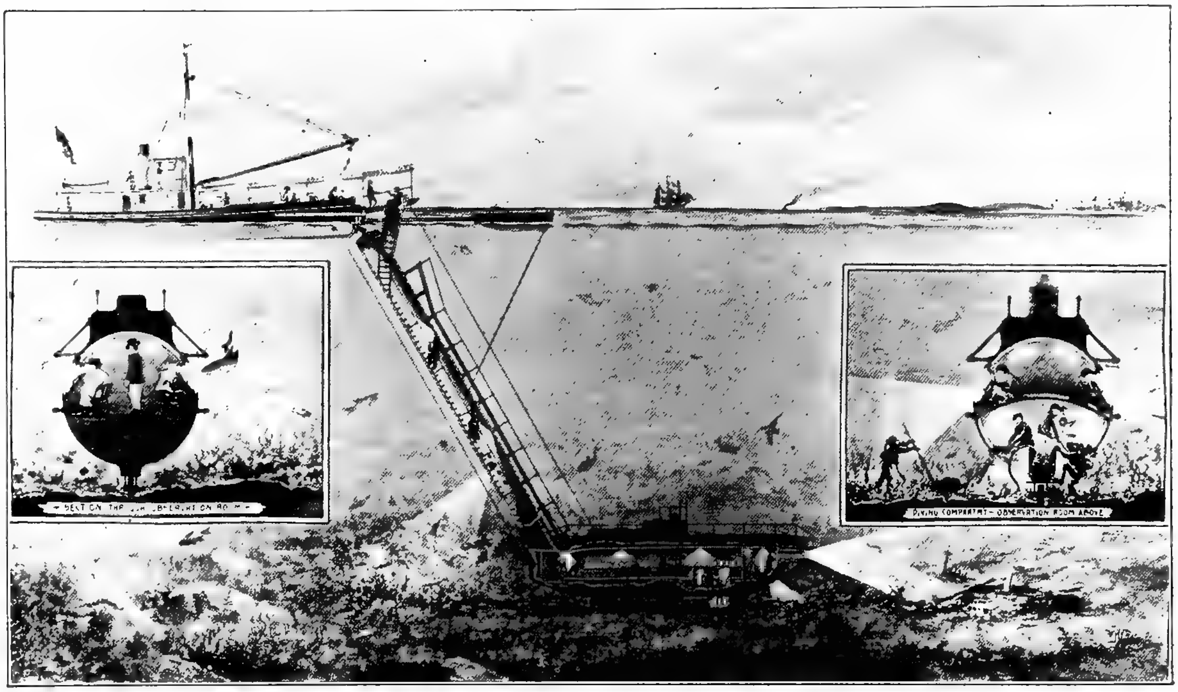
says: "She was frequently submerged, retaining an even keel on the surface, and answering readily the requirements of the pilot. The problem of submarine navigation and attack is approaching a solution." In 1892 the submarine boat *Audace* was launched at Foce, Italy, for fishing and recovery of sunken treasure.

At this juncture, Simon Lake entered the scene, and his work was foremost in leading up to the great development of recent years, in which he has continued to play a foremost part, as an inventor of the even-keel type of electric submarines. He built in 1894 his first boats which attracted notice immediately; and in 1897 he launched the *Argonaut,* the first submarine—and electric at that—to operate successfully in and under the open sea. Another noted American inventor of electric submarines of the same

period was John Holland, and the boats of his construction and design did much to lead up to the present time, when submarines carrying heavy naval guns, or making the voyage across the Atlantic and back, are accepted as a matter of course.

MOTOR BOAT EQUIPMENT

Meanwhile the uses and advantages of electricity have been more and more recognized for all classes of vessels, small and large, for auxiliary purposes. One notable field which was opened up to electrical exploitation was that of the motor-driven boat. Here a suitable source of current supply and especial desirability of electrical application, both from the standpoints of convenience and of safety, were combined. For the motor-boat the use of electricity as an illuminant is imperative, as the danger of fire or explosion, which is always present when other means of lighting are used, is entirely eliminated with electricity Lamps can be placed in any part of the boat and in any position needed, can be controlled by a main switch, individual switches, or by both, and singly or in various combinations. They can be used in the running lights, the anchor light, and the searchlight. When electric outside lights are used, they can be connected in such a way that should any one of them become extinguished, both visible and audible notification of the fact is instantly made by a "telltale" board, usually placed in the engine room. Of the advantages of electric service on motor boats none is more evident than the facility it affords for the instantaneous turning on of light in any or all parts by the mere movement of a switch. But while electric lighting is in general use on motor boats, large and small, there is also a more or less general adoption, on such boats of the larger class, of additional equipment for heating and cooking. Ingenious gasolene-electric generating sets have been for several years on the market, which are admirably adapted to use on vessels propelled by gasolene engines. Special electric ranges and ovens for ship's kitchen, luminous radiators for heating, and a complete line of electrical devices used in cookery and especially



The Simon Lake Submarine for Deep Sea Exploration

adapted for marine installations are manufactured for use on the modern, electrically equipped motor-boat.

ELECTRICITY ON OCEAN LINERS

Ocean liners early adopted electric lighting, the advantages of which, both because of its unequalled efficiency as an illuminant, and of its practical elimination of the element of danger, soon made it indispensable on shipboard. But the larger use of auxiliary electrical applications has also come within the past ten years on the ocean liners, and has been rapidly followed on freighters. The fact that the adoption of electrical power equipment on all seagoing steamships was delayed so long after the complete acceptance of the electric light on shipboard, probably may be attributed to the general hesitancy of marine designers and engineers about approving devices for seafaring service merely because they had proven their value in land operation. It has, indeed, often turned out that machines which have worked excellently ashore have lacked qualities absolutely necessary for their successful employment under the different conditions that are involved in marine use and continuous service afloat.

But after a beginning was made in the installation of electric motors to replace steam engines for power purposes on board ship, the use of such motors was rapidly and wonderfully extended until now electricity substitutes steam in practically every power application on board the ship except the actual propulsion of the vessel itself, and even for that major purpose has recently been adopted in several very noteworthy instances. Many applications of power for which the steam engine had always proved unsuitable are easily accomplished by means of electrical installation. In the modern ship's engine room all classes of auxiliary machines are now driven by electricity, including pumps, refrigerators, turning and lifting gears, forced draft and ventilating fans, steering gear, ash hoists, and others; and on the decks, winches, cranes, capstans, lifeboat gear, fans for ventilating compartments below decks which would under non-electrical conditions either be left entirely unventilated or dependent upon windchutes or other uncertain or at best inadequate action; also elevators for passengers, baggage, ship stores; and in the kitchen and culinary departments for many time-saving operations. Applications to wireless telegraphy, and for the ship interior telephone plant were among the earliest power installations to be adopted aboard ship.

Mr. C. E. Jones, an English electrical engineer who has been prominently identified with electrical applications on shipboard, in a paper read before the Liverpool Engineering Society, December 15, 1915, enumerates "some of the advantages gained by the installing of electrical machinery, such as absence of vibration and noise, and small space required." He calls attention to the sightly and pleasing manner in which cables can be installed, without in the least interfering with interior decorations, and how every trouble and disadvantage incident to the use of steam pipes is overcome by the substitution of electricity, which eliminates the possibility of damage from heat and leaky joints and the loss due to radiation.

He states that "cables are much neater, cleaner, require considerably less room than steam pipes, and do not need the attention continually demanded in keeping the steam joints tight. High efficiency, low wear and tear, and little need of attention are factors directly in favor of electrical machinery."

A typical electric installation on a large, modern, well-known liner consists of four engines and dynamos, each dynamo having a capacity of 400 kilowatts at 400 volts. Engines and dynamos sit on a platform in the turbine engine room 20 feet above the water line, the engines each being connected to boiler by separate steam pipe, so that should the main set be temporarily out of action they can provide current for such lights and power appliances as would be required in the event of emergency. Working in connection with the emergency sets is a storage battery capacity of about 3,500 ampere hours, situated on the promenade deck forward of the first-class smokeroom, providing stored energy in ex-

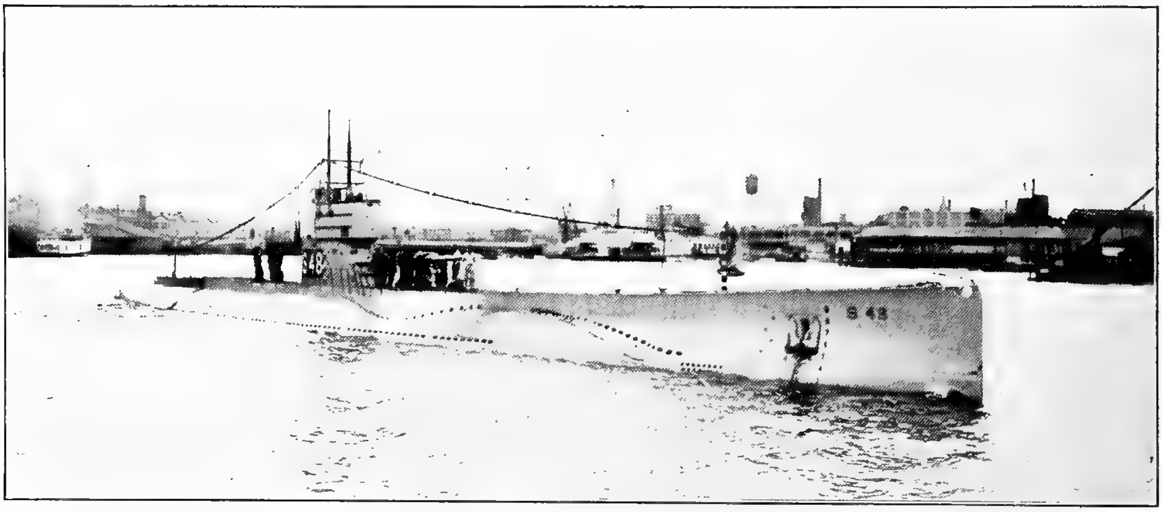
treme emergency for an independent installation of 500 lights, together with wireless, etc.

The electric lighting on such a steamship is equal to that of a good-sized town, the total number of incandescent lights being about 11,000, ranging from 8 to 16 candle power. There are special dimming lamps in the first-class rooms, and the electric bell system includes 1,700 bell pushes and 29 indicator boards distributed all over the vessel; and an alarm bell and indicator in the chart room.

There are electric heating, power and mechanical ventilation devices in service, represented by 188 motors and 600 electric ventilators installed throughout the vessel. The system of ventilators consists of electrically-driven fans, in many cases provided with steam coils for warming the air. Loud-speaking telephones of navy pattern are fitted for communication between the wheelhouse on the bridge and forecastle; and after docking, bridge, engine room and wireless room, and also in the chief engineer's cabin.

The telephones are operated both from the ship's lighting circuit, through a motor-generator, and alternately by a stand-by storage battery, which is introduced in the circuit, if the main supply should fail, by means of an automatic switch. There is also a separate telephone system for intercommunication between a number of the chief officials and service rooms, through a 50-line exchange switchboard. Many of the pantries and galleys are also in direct telephonic communication.

The apparatus for wireless telegraphy consists of a 5-kilowatt motor-generator. The house for the instruments is situated on the boat-deck. There are four parallel aerial wires extending from the mast, fastened to light booms; and from the aerials connecting wires are led to the instruments in the house. There are two complete sets of apparatus, one for transmitting and one for receiving messages, the latter being received in a sound-proof chamber in one corner of the house. There is also an independent storage battery and coil.



The Simon Lake Commercial Oceanic Submarine

For submarine signalling, apparatus is provided for receiving signals from submerged bells. Small tanks, containing microphones, are placed on the inside of the hull of the vessel on the port and starboard sides below water, and connected by wires to receivers situated in the port navigating room. The whistles are electrically actuated. The boiler room telegraphs, stoking indicators, and numerous auxiliary appliances, such as rudder indicators, clocks and thermostats, are also electrical; and the watertight doors are released by electromagnets.

MODERN BATTLESHIPS

Even more extensive and comprehensive is the auxiliary electrical equipment of modern battleships. The lighting system is as complete as that of the ocean liner, and the power applications are even more so. The signalling system is another important electrical auxiliary on board of a man-of-war, and now very nearly equals in cost the power and lighting system. The service it performs has many subdivisions, comprising telephones, telegraphs, call-bells, voice-tubes, control of gunfire, etc. Although mechanical telegraphs are still retained for the main signals for maneuvering the vessel, establishing communication between the bridge and the engine-room, yet electrical instruments parallel them and perform all other functions of communication.

ELECTRICAL PROPULSION OF SHIPS

There is, therefore, no longer any question or controversy as to the value and demonstrated usefulness of electrical equipment of vessels for any or all of the auxiliary purposes for which they are used, but a matter of large technical and practical interest is involved in the question of the comparative efficiency, reliability and economy of the propulsion of ships, and especially of large vessels, both of the merchant marine and of the navies, by electric drive.

The decision of the United States naval authorities to adopt a system of electrical propulsion for the large, new battleships and battle cruisers has aroused renewed interest in the use of the electric drive for ship propulsion. That the electric drive has many advantages is conceded, but it has been contended by many shipbuilders and by some prominent engineers that the modern double-reduction mechanical gearing gives a system equally advantageous, which is at the same time free from the disadvantages (chiefly those of increased initial cost and increased weight) of the electrical reduction gear. There are, however, limits to the ratio of reduction that can be obtained with the mechanical reduction gear, even when it is of the double-reduction type, and therefore, while the tendency of turbine design is toward the production of machines of higher speeds of rotation, a limit is reached beyond which the speed of the turbine cannot be run if mechanical reduction gearing is employed and an efficient propeller-speed is desired.

Electric drive is not a new thing, though its application to vessels of the type and class specified for the seven battleships and five battle-cruisers now under construction is a tremendous stride forward, especially when it is remembered that the only warship to be previously electrically driven was the U. S. collier *Jupiter*. Electrical propulsion was in its early experimental stage when it was adopted for the *Jupiter* in 1912. At that date the only vessels of any important size or function to be electrically driven were the Chicago fireboats with turbine driven direct-current generators and twin motor-driven screws, which were not only propelled, but also steered through the vessel-thronged Chicago River by their own two motor-driven propellers.

The U. S. naval collier *Jupiter*, deriving its propulsive power from alternating current generators and motors made 14.78 knots per hour on her sea trials, exceeding her guarantee by nearly three-quarters of a knot, and has been in successful operation ever since 1912. Her electric drive has proved to be as fully efficient at it was claimed to be, and, not only that, she has served as an experiment station of electrical equipment, the study of which led the technical experts of the Navy Department into the appreciation of electric drive as a means of battleship propulsion which found concrete expression in the Naval bills of 1915 and 1916 which authorized the fleet of new battleships and battle cruisers.

Meanwhile there has been a marked advance in the use of electric drive for ship propulsion as applied to merchant vessels. The *Tynemount* was completed in England in 1913, and designed for operation on the Great Lakes of North America as a freighter. The ship measures 250 feet in length and 42.5 feet in beam, with a 19-foot draft, and was at that time about

the largest ship to be equipped with electric drive. Her prime-mover equipment is of the Diesel internal-combustion type, the engines driving alternators which in turn operate the 500-h.p. motor which drives the single propeller. Use can be made of the ship's double-bottom for carrying an extra supply of fuel oil in addition to the contents of the two tanks on deck forward of the poop bulkhead. There are two 6-cylinder high-speed internal combustion engines of the Diesel type, each capable of developing 300 brake-h.p. at 400 revolutions per minute on the 4-stroke cycle, the diameter of the cylinders being 12 inches and the stroke 13.5 inches. The engines are totally inclosed, forced lubrication being used throughout. The electrical equipment consists of two 3-phase alternators, each direct-connected to one of the Diesel engines. The alternators, when running at full load at their normal speed of 400 r.p.m., generate a pressure of 500 volts, and currents of 270 amperes per phase. They are provided with 6 and 8 poles respectively, making the frequency produced by one 20 cycles per second, and that of the other 26.6 cycles per second. An exciter is directly connected to each alternator capable of giving an exciting current of 30 amperes for ordinary operation, which can be increased to 50 amperes while maneuvering. The output from the two generator sets is led to a 500 brake-h.p. induction motor. The two alternators, when both at work, are connected to two entirely separate circuits, and they are therefore never run in parallel. The switching apparatus is simple, easily controlled, so constructed that the handling of the ship can be carried out by means of two levers, which are so interlocked as to be practically foolproof. They are actually installed in the engine-room, but by lengthening the connecting cables could be placed on the navigating bridge. Use of electric drive enables speed to be altered without altering engine speed, and also permits a convenient gear ratio, enabling the engines and propeller, respectively, to be run in their normal direction. In many cases the electrical system admits of a reduction in the machinery space, and also in the bunker space required, thus increasing the cargo space of the vessel.

The progress of electrical propulsion was still more strongly accelerated by the result of the work done by the Ljungstrom Turbo-electric system as exemplified in the equipment of the steamship *Mjolner*, one of two sister ships built for the Stockholms Rederiakhebolag Svea, the most important ship-running company in Sweden, the other being the steamship *Mimer*. It had been intended to make them twin ships in all details of design and equipment, and the *Mimer* was equipped with triple-expansion reciprocating engines, but the Ljungstrom Company proposed to the Svea Company to equip the *Mjolner* electrically with its turbo-electric machinery under guaranty conditions that the electrical ship should not exceed 70 per cent. of the fuel consumption of the steam-driven ship.

The consumption of the *Mjolner* in this test was 42.3 per cent less than that of the *Mimer,* while her development of both indicated and shaft horsepower was much greater.

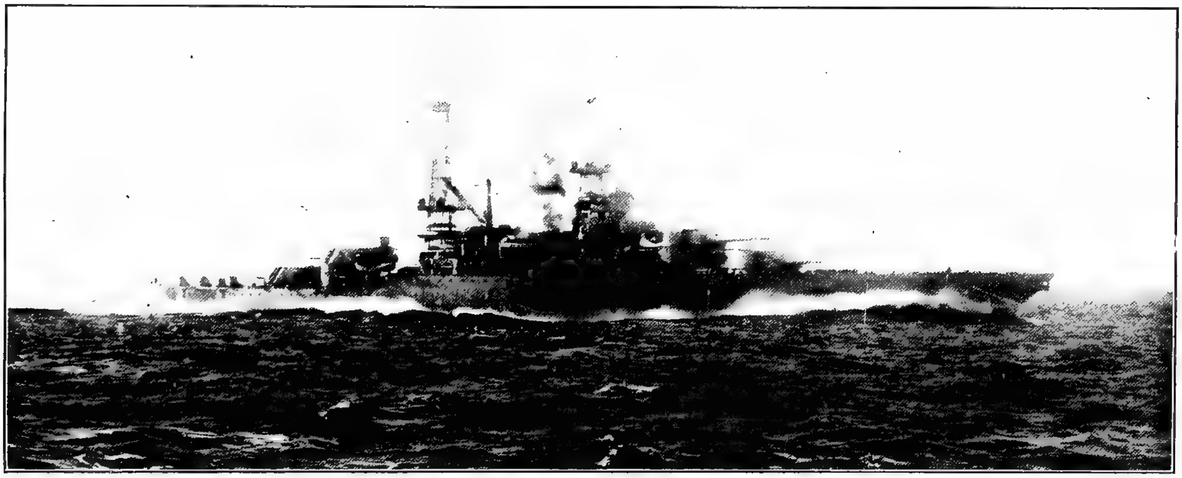
In actual work, both vessels running in coasting trade and under similar conditions, the steamship *Mimer* from January 20, 1915, to May 3, 1915, covered 4,450 nautical miles, and during that period burned 361,000 kilograms of coal or 81.1 kilograms per nautical mile. The propelling plant of the *Mjolner* consisted of two turbo-generators of equal power, delivering their power electrically to two motors, each of them driving a pinion engaging through helical gearing to a common wheel attached to the propeller-shaft. From January 31, 1915, to April 28, 1915, the *Mjolner* covered 6,378 nautical miles and during that period consumed 319,780 kilograms of coal or 50.4 kilograms per nautical mile, using 32 per cent less coal than the *Mimer.*

Subsequent installations by the Ljungstrom turbo-electric system, on larger vessels produced results equally favorable for the electrical equipment, and up to December, 1917, there had been contracts placed for its installation under that system, on forty-three vessels, aggregating 78,250 horsepower. This, up to date of writing,

was the most extensively used service that has thus far been equipped with electrical propulsion.

In 1921, the *Eclipse,* the pioneer electrically propelled cargo ship of the American merchant marine, completed successfully its first voyage, a 5,000-mile non-stop trip from New York to Port Said, Egypt. Heavy seas were encountered, but it is reported that good speed was maintained with no mishaps.

The *Eclipse* was built by the Union Iron Works, San Francisco, in 1918. In 1920, its original propelling apparatus was changed by the Shipping Board to the turbine electric form of propulsion at the yards of the Vulcan Iron Works, Jersey City, N. J. It was chartered by the Government to the American Line of the International Mercantile Marine. Its electric equipment consists of a steam turbine and a 2,300-volt generator driving a 3,000-hp. motor at 100 revolutions per minute and control apparatus for maneuvering the vessel. The ship is 440 feet long, 56 feet wide and of 11,868 tons displacement.



The Electrically Driven U. S. Dreadnaught Battleship *New Mexico*

APPLICATION OF ELECTRICAL PROPULSION BY U. S. NAVY

But, gratifying as the outlook is in the mercantile field, by far the most important of the developments of electrical propulsion have been made by the decision of the Navy Department to adopt electric drive on the new battleships *New Mexico, Colorado, Washington, Maryland, West Virginia, Tennessee* and *California*, and five battle cruisers. The battleships are of the largest type, requiring for their propulsion 33,000 horsepower each, but these are commonplace in power requirements compared with the great battle cruisers, the power requirements of which involve the most stupendous propulsion problem ever presented for engineering solution, since they require no less than 180,000 horse-power each. The vessels are designed to make a speed of 35 knots each with this full power delivered to four shafts running at full speed about 250 revolutions per minute.

The *New Mexico* battleship, first of the innovating type which represents as great a departure from naval traditions and practices as did the introduction of the ironclad man-of-war in place of the former "wooden walls," such as the British *Victory* or the American *Kearsarge*—is a leviathan of 32,000 tons. To drive her at full speed of 21 knots requires 28,000 horsepower. She has nine boilers in 3 boiler compartments of 3 each, and has a shovelless fireroom as she uses oil, carrying tanks of about 1,000,000 gallon capacity. The boilers furnish steam to two huge electro-turbo generators, at a steam

pressure of 250 pounds at the throttle. Each of the steam turbines is capable of developing 16,000 horsepower, and each unit is in a compartment of its own, low down in the hull, which is in itself an advantage from the point of view of actual warfare. Besides, one of the advantages of the *New Mexico* power room is the fact that there is only one steam pipe in each room, and that one is only 16 feet long. Each of the two main turbines is connected to a quarter-phase generator having two-poles. The four propelling motors receiving current from them are wound in such a manner that by changes of connection effected through groups of oil switches on the control board, the windings can be arranged for either 24 or 36 poles. The ratio of speed reduction, therefore, between the turbine and the propeller is approximately 12:1 to 18:1. The 36-pole connection is used for all low-speed running, up to a maximum of about 15 knots. Above that the 24-pole connection is used. All reversing is done with the motors connected for 36 poles. For all conditions of steady running up to, say, 15 knots, only one turbine unit with its associated auxiliaries is used, and all the motors are connected for 36 poles, giving a speed ratio of 18:1. If a higher speed is required, the pole connections are changed from 36 to 24, giving a ratio of 12:1, and a speed of 17 knots is thus obtained with one generating set running. The windings of the generator are then connected in multiple so as to reduce the voltage, which increases the current capacity of the generator, giving also increased torque and better efficiency. Above that speed, the second generating unit comes into play. With that final arrangement, each generator operates a pair of the motors; and the two circuits are entirely separate from each other. In this condition, the generator windings are connected in series so as to give the desired higher voltage for maximum speed. The ship can be started on one or both generating units, and with the motors connected for either 36 or 24 poles. When both generating units are used for steady running, the motors are always connected for 24-pole operation. All reversing is done with the motors connected for 36 poles. All switching, pole changing, etc., is done on a dead short-circuit. The switches can, however, be operated under full-load conditions, if emergency requires. Interlocks are provided, by which it is impossible to move any of the switches without having first interrupted the field circuit of the generator and allowing the line current to die down to a predetermined low value. Each generator is also provided with a set of balanced relays. Should trouble of any kind occur there is an unbalanced distribution of current in the solenoids operating these relays; the system becomes unbalanced and the field circuit of the main generating unit is thus opened. Hence any ground, defect in insulation, etc., can be located before any serious difficulty occurs.

For excitation, two 300-k.w. turbine direct current sets, arranged for 1,200 or 2,400 volts, provide the necessary current. There are also two motor-driven boosters for each generator field, which can either raise or lower the pressure 60 volts. Hence, if the field is connected to the 240-volt circuit, the excitation voltage can be varied from 180 to 300 volts; and if on the 120-volt circuit, from 60 to 180 volts. In order to obtain quick reversal, increased field excitation is always used, and is obtained by pulling the field lever by hand against a heavy spring, which brings the excitation back the instant the lever is released. When operating at full load and about 2,000 r.p.m. each generator requires 38,000 cubic feet of ventilating air per minute. There are fans at the end of each rotor, but these are supplemented by separately-driven blowers, each capable of delivering 20,000 cubic feet of air, at a speed of 380 r.p.m.. In like manner each main motor has two blowers, each passing 10,000 cubic feet per minute, driven by d.c. motors of 8.5 h.p. each at a speed of 510 r.p.m. In addition to the four 20,000-cubic feet blowers, there are two similar blowers which supply air to the central engine room, where are located the two main motors driving the inboard propellers, as well as all the engine room auxiliaries and propulsion control apparatus.

THE 100 PER CENT ELECTRIC SHIP

At this juncture, it seems appropriate to summarize the remarkable electrical equipment of what has been justly and cleverly characterised as "the 100 per cent electric ship." It is as follows:

ELECTRICAL EQUIPMENT OF *NEW MEXICO*

2 main generators	31,000 h.p.
4 motors for propelling	28,000 h.p.
6 dynamos	2,400 h.p.
6 air compressors	300 h.p.
2 steering gear motors	250 h.p.
20 motor generator sets totaling about	100 h.p.
4 boat crane motors	200 h.p.
2 anchor motors	350 h.p.
4 winch motors totaling	200 h.p.
1 capstan motor	50 h.p.
20 turret motors	500 h.p.
10 ammunition hoists	50 h.p.
2 refrigerator motors	40 h.p.
8 motors in kitchens	15 h.p.
6 in carpenter shop	20 h.p.
15 in machine shop	30 h.p.
6 in laundry (5 machines use electric heat)	10 h.p.
5 motors in printing shop totaling	6 h.p.
14 water pumps	140 h.p.
4 oil pumps	8 h.p.
50 electric air heaters	150 h.p.
12 searchlights	200 h.p.
160 fans, 60 blowers, 6 electric toasters, 1 electric percolator, 15 electric irons, 104 loud speaking telephones, 176 ship service telephones, 170 fire control telephones, 2 electric gyroscopic compasses.	
7 portable electric drills, 2 electric glue pots, 6 electric soldering irons.	

Nor is this all, wonderful as the list is, which is not even exhausted or made complete by reference to the 104 loud-speaking telephone sets located all over the ship, and by means of which from three transmitting stations, bugle calls or instructions can be sent to all or any one of five different telephone groups. Electricity contributes also greatly to the comfort of some 1,100 officers and crew on board the *New Mexico*, by such varied means as electric fans, potato peelers, ice-cream freezers, meat cutters, dish washers, butter cutters, knife sharpeners, metal buffing and polishing machines, dough mixers, clothes washers, irons in the tailor shop, coffee percolators, and, in fact, more than all the devices now known to the domestic economy of the modern "House Electrical."

Returning for the moment, however, to the direct question of electrical propulsion, we may quote pertinently in closing, Mr. W. L. R. Emmet, who has had more to do with carrying through this development, it fairly may be said, than any other man. He remarks in the course of a general discussion:

"The most important advantages afforded by electric propulsion in a large warship are that it introduces the feature of interchangeability by which the ship can be quickly put into operation after a portion of the apparatus has been damaged, and that it furnishes a means by which the ratio of speed reduction between the propellers and turbines can be changed; thus cruising speeds can be handled by a part of the apparatus without the sacrifice of efficiency which would be occasioned by a reduction of the turbine speed.

"Other important advantages are that vital parts of the propelling machinery can be put into separate small compartments in those parts of the ship which are least subject to damage, and that no high-speed mechanisms or parts involving mechanical engagement are attached to the propeller shafts; thus the propeller shafts are free to revolve at all times whether they are being driven or not. No trouble which could occur in such electric motors would interfere with the freedom of their turning.

"In electrically-driven ships the most advantageous speed of both turbine and propeller can be adopted, separate turbines for reversing can be dispensed with, and a high torque for reversing is readily obtainable.

"The abandonment of the reversing turbine renders unnecessary the delivery of large flows of steam to turbine elements that are either standing still or moving in a reverse direction. Under certain conditions and in turbines of certain sizes, such reversing action may not be objectionable, but it involves the possibility of very high temperatures and it is probable that these temperature variations have constituted a fruitful source of trouble in ship turbines. The use of very high superheat, which with electric drive constitutes a perfectly

safe method of obtaining a high degree of fuel economy, will unquestionably involve danger in reversing operations with geared turbines, and these dangers are likely to be most serious in large units designed for high efficiency.

"In ship propulsion through turbines and gears, it is desirable in all cases involving large power to use a plurality of turbines for each propeller; whereas with electric drive each propeller is driven by but one turbine or by a part of the power received from one. A subdivision of turbine units involves considerable loss and complication due to the multiplication in the number of packings, and also it involves a loss of pressure and liability to steam and air leakage in the cross-connections between different units.

"While the simple operation of transmitting power through gearing is more efficient than its electrical transmission through generators and motors, the difference in large units is much less than has been generally supposed; and it is in a great measure compensated for by the friction load occasioned by the reversing turbines and by the disadvantages incident to the use of a plurality of turbines instead of one. If, in the interest of the gear proposition, anything is sacrificed in turbine speed or design or in the degree of superheat adopted, the electric drive will show an advantage even under the conditions for which the geared turbine is best adapted.

"While much good service has been performed by geared-turbine equipments in ships, experience has shown that their success is dependent upon great accuracy of manufacture, that they are subject to injury through vibrations in the ship's structure or through wear in bearings or insecurity of mountings. Electric propulsion involves no motion other than simple rotation and this gives a maximum of mechanical simplicity.

"Justification for electric drive on merchant ships is that it affords a transmission efficiency practically equal to that obtaintion, and that it accomplishes this result by a simpler and more reliable means."

One more branch of the general subject may be briefly referred to.

THE ELECTRICALLY-RIVETED SHIP

There remains yet one more department wherein electricity is affecting the arts of ship building, equipment and propulsion—namely, the field of manufacturing ship hulls. The ship launched recently in England with an electrically-welded hull, is only of 500 tons, but she serves already as an example and as an encouragement to the enthusiastic advocates of the great modern art of electric welding even now so widely applied in many diverse branches of mechanics and engineering. On this subject, we may quote Mr. James G. Dudley, of the Merchant Shipbuilding Corporation, who says:

"The highest technicians in the United States Navy are eager advocates of this revolutionary method of ship-fabrication and repair, and have employed it upon a very large scale and upon structures of prime importance. Naval designers and inspectors have displayed the most sympathetic and progressive attitude toward this new aspirant for honors—notably in the design and execution of a great seagoing battleship target wholly by such means, and in addition by unqualified indorsement of electric welding for the dramatic and highly efficient repair, in record-breaking time, of the power plants of the interned German vessels.

"A critical survey and analysis of 'ship-building as she is wrought' generally throughout the world to-day—whether in Japan, Germany, France, England, or the United States—fully taking into account the new outlook and attitude of ship labor, as well as the economic conditions surrounding this great industry, warrant the deliberate statement that: 'There is not now in sight, or liable to be hereafter, any probable material improvement in the art or technique of riveting or even in the attained or attainable speed thereof over what pretty generally now prevails.'

"In the United States to-day practically all the ship-riveting is carried out by means of compressed-air tools, and from coast to coast and from the Great Lakes to the Gulf of Mexico the maximum average which has been achieved, or which may be looked for, is well under four hun-

dred rivets per gang of four riveters per day of eight hours. In Japan and England, at least, these figures are unquestionably matched by skilled riveters, who drive their rivets exclusively 'by hand'—that is to say, without the use of pneumatic tools.

"Authentic records of old-time Delaware River shipyards disclose the remarkable fact that the aforesaid 1920 maximum average was exceeded by fully 50 per cent more than ten years before the opening of the world-war, when no 'modernized' equipment was employed. In one respect alone does it seem possible materially to improve the riveted ship—and that is in a better control, and reduced cost, of the 'bolting-up' operations, which must now necessarily precede the actual riveting. Many attempts, and some partial successes in increasing the efficiency of 'bolting-up' operations were devised during and since the war, but their general effect has thus far been negligible. In electric welding alone is there any great promise of advancement in the art of shipbuilding, and that promise lacks only vision, courage, initiative, money, and skilled technicians to bring about a veritable revolution or—all signs fail."

While the preparations are thus being made for the electrically-welded ship, quite an advance has been made in the development of electric cast-steel anchor chain to moor the ships with. This was done under the auspices of the Emergency Fleet Corporation and in May, 1918, an order for about $1,000,000 was placed by it, which saved the U. S. Government not less than $50,000, with gains in manhours, machinery, fuel and transportation costs, as well as in reliability.

CHAPTER V

THE STORY OF ELECTRICITY DURING THE WORLD WAR

THERE were many special aspects of electrical application during the World War, and they constitute unavoidably a separate chapter, which appropriately may be called "The Story of Electricity During the Great War." As a matter of fact and of historical record, what happened divides itself into two sections: The story of the three years before the United States "went in" and that of the glorious results.

All departments of electrical industry showed immediately the effects of the World War from its very inception in August, 1914.

One of the early steps, when the United States entered the war was the issuance of a series of proclamations under which all the public utilities passed under governmental control or operation. President Wilson's proclamation said: "It is deemed necessary for the national security and defense to supervise and take possession and assume control of all telegraph and telephone systems, and to operate the same in such manner as may be needful or desirable." This meant placing both systems in the hands of Postmaster General Burleson, who in a formal statement said that the war difficulties could thus only be overcome by a unity of administration—particularly a unification of the use of the telegraph and telephone lines, which could not be realized without the aid of the government. Mr. Burleson said that thus a "greater opportunity was afforded to effect improvements and economies and a larger use by the people of these facilities." Cable and radiotelegraph systems were taken over a little later, but in their case the control was vested in the Navy Department. It is not necessary here to go into any details as to the governmental management of the telegraph and telephone, but the statement confidently may be made, that as in the case of the steam railroads, the results killed any national desire for a continuation of such governmental control, and silenced decisively and even brusquely any further advocacy of such a system of operation. In many quarters the belief is entertained that neither the telephone nor the telegraph systems can soon recover the vigorous initiative and spirit of progress which they had magnified under the regime of private ownership.

With regard to the electric light and power industries, conditions were somewhat different; and different again with respect to the street railway systems of the country. Mobilization for war was the fate of all American activities; and these newer agencies of civilization were also, and very speedily, swept into the arena and tested under new and strange processes of trial. Some remarks made by President Charles L. Edgar, of the Edison Electric Illuminating Company of Boston, when the war was at its height in 1918, are graphic and pertinent: "I think I am justified in saying that 90 per cent of my thought the past year has not been with the Edison Company, but with the work of the government. I was told by my directors when the war started that I might have a year's

leave of absence, but I thought I could do better service along the line in which I have been working. I thought I would be of more use to the community and to the country in dabbling in a lot of things as I have, rather than by cutting loose and giving my entire time to one thing." Such was the spirit and attitude of the managers of all these utilities throughout the country at a time when the plants or the output had been commandeered, when a large proportion of their best men had gone into the ranks of the American Expeditionary Force for kindred war service, when fuel supplies were reduced to a painful minimum, when priority orders of all kinds crippled operation, and when rates allowed by Public Service Commissioners were far below the point of adequate safe return at which the properties could be maintained and developed. The aspect was indeed so serious at one time that President Wilson felt impelled to make a notable plea and said: "It is essential that these utilities should be maintained at their maximum efficiency and that everything reasonably possible should be done with that end in view. I hope that state and local authorities where they have not already done so, will when the facts are laid before them, respond promptly to the necessities of the situation." Although by no means all has been done that could or should be, by Public Service Commissions or other authorities, many public utilities thus had their rates advanced to grant them relief and enable them to give the public proper service. Per contra, the utilities and their managers throughout the war period were like Mr. Edgar conspicuously energetic in discharge of patriotic duties,—subscribing largely to Liberty Loans, raising large funds for Red Cross and other philanthropic efforts; assisting in all manner of local work, and caring alike for their employees volunteered or drafted for the war and for the families and dependents left behind. As a typical instance might be mentioned Mr. Arthur Williams of the New York Edison Company, who for several years was tireless in active work as the Federal Food Administrator for Greater New York, one of the many "dollar a year" men who gave their best thought, time and effort to national purposes. There were also formed various committees and bodies to assist departments of the government, as for example the National Committee on Gas and Electric Service of which Mr. John W. Lieb was chairman, and the analogous body in the American Electric Railway Association which found its ideal exponent in Mr. Philip Gadsden. It should not be overlooked that the electrical manufacturers of the country, so closely allied with the electrical public utilities as the source of apparatus and supplies, were also very much alive in all such work, especially through the General War Service Committee of the Electrical Manufacturing Industry, which with Mr. W. W. Nichols as chairman, served as a connecting link between the government and the various groups of electrical manufacturers in regard to the ability to produce material essential to the prosecution of the War. Brig. Gen. Geo. H. Harries not only served with distinction during the actual fighting, but after it was over was sent by General Pershing and President Wilson to Berlin as head of the body to release, relieve and send home the hundreds of thousands of prisoners who still survived their sufferings in the prisons and prison camps of the Central Powers. It was a benefaction of the greatest difficulty, danger and magnitude. Note may also be made of the fact that many electrical men gave valuable domestic non-military service like Brig. Gen. Guy H. Tripp. Several were recognized and decorated by their own and foreign governments, such men as Col. John J. Carty and Col. H. M. Byllesby receiving the Distinguished Service Medal.

Another phase of the subject was presented in the activities of the electrical technical bodies, either by themselves or in necessary cooperation with other engineering bodies. The first step was taken by a joint committee of such societies cooperating with the War Department, as early as 1915 in the organization of a National Engineering Service. The direct result of this work was the provision by Congress for an Engineer Officers' Reserve Corps from which a large number of commissioned engineers was selected. It was reported that in January, 1918, no

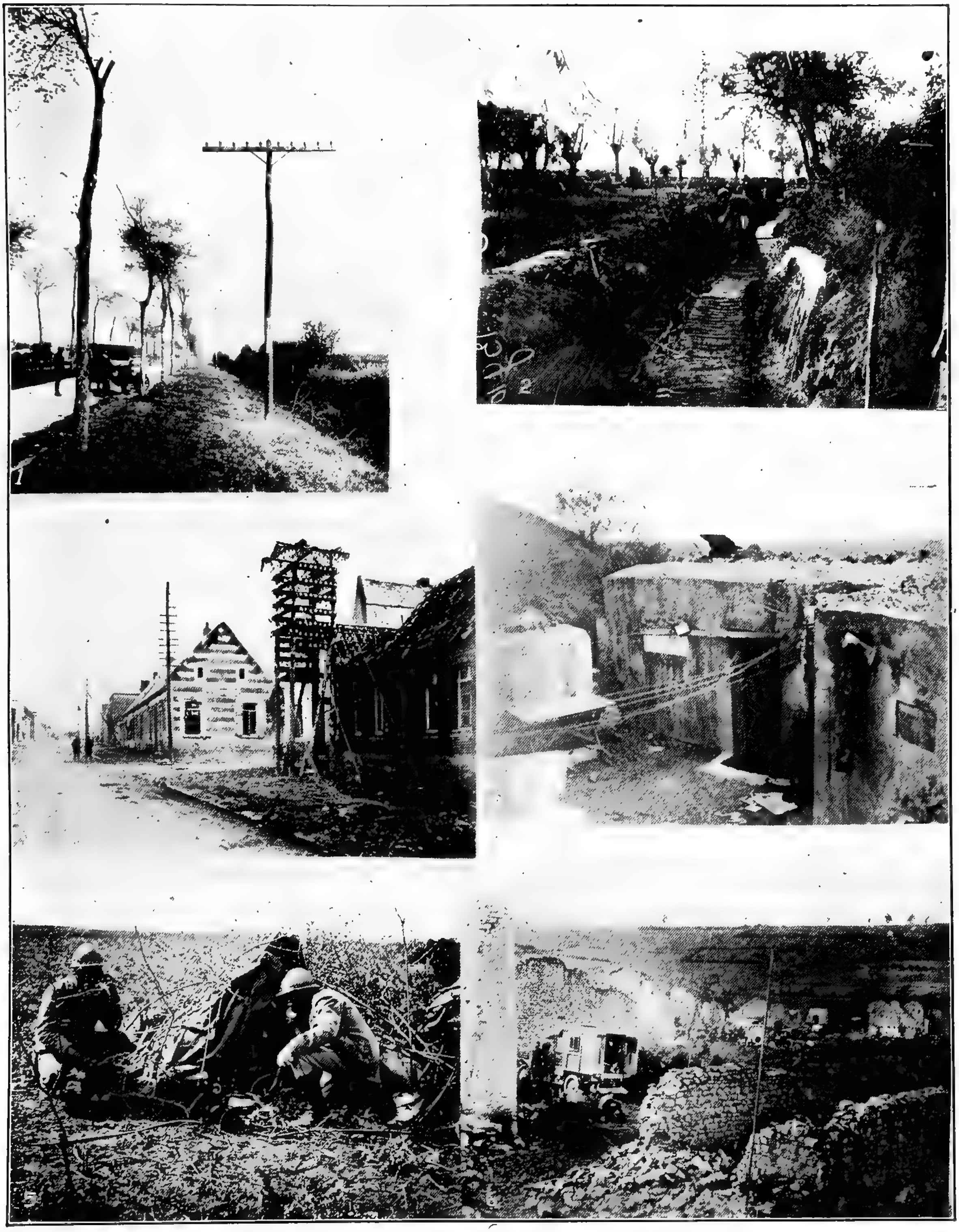
fewer than 338 engineers had been thus appointed as captains or of higher rank from the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. The former body sent out a brief military data sheet to all its domestic membership, and more than 2000 of these filled-out sheets were forwarded to the Institute's representative in Washington, chairman of its committee on national defense, and turned over by him to the various departments of the Army and Navy. From them men were selected according to their qualifications, to whom also were sent application forms for admission to the Reserve Corps. In this and other specific ways the American Institute of Electrical Engineers assisted the government in obtaining the services of technical men for the following branches of service. By request of the Bureau of Navigation it nominated 85 graduate electrical engineers for appointment as lieutenants, junior grade, U. S. Naval Reserve Force; U. S. Bureau of Yards and Docks, similar candidates for appointment with the ranks of ensign, junior lieutenant, and lieutenant; Bureau of Chemistry, electrical and mechanical engineers for special investigations throughout the country; U. S. Signal Corps, electrical men for the radio division and the aviation section; Bureau of Navigation, candidates for aviation inspection duty for training as ensigns in the Naval Reserve Flying Corps; U. S. Coast Artillery School, department of enlisted specialists, draftsmen, engineers, electricians and radio operators, as temporary non-commissioned officers.

The Illuminating Engineering Society did analogous work along somewhat different lines, and through its special Committee on War Service was able to be of considerable use to the government in the design of lighting for building and grounds of aviation camps and for night flying; and also in the design of lighting for other buildings erected by the Navy and War Departments. At the request of President Samuel Gompers of the American Federation of Labor, the Society nominated two members to serve with the Committee of labor of the Council of National Defense to deal with the question of factory, mill and workshop lighting—(1) to conserve the eyesight of workmen; (2) to make factories safe by proper lighting; (3) to increase the efficiency of workmen by giving proper lighting; and (4) to increase output and decrease spoilage.

THE NAVAL CONSULTING BOARD

The first of the civilian agencies formed under the new conditions created by the Great War to assist the government in dealing with its novel and stupendous problems was the Naval Consulting Board, which was promptly organized when in January, 1917, Secretary Josephus Daniels of the Navy Department invited Mr. Thomas A. Edison to become its head and, in addition, to devote himself personally to the study and suggestion of such ideas and inventions as might seem to Mr. Edison likely to be useful when the United States joined the Allies and became involved in war with the Central Powers. The Board was formed under the plan of inviting the chief engineering societies of the country to select fitting and available members and to nominate them; as the result of which a very fine and representative group was assembled which took its duties very seriously, met frequently, and did a large amount of useful work, of which up to the present moment the official record has not been generally made public, and some of it will probably be kept secret in the archives of the U. S. Navy. Many well known electrical men were members of the Board with Mr. Edison, including Messrs. Frank J. Sprague, Elmer A. Sperry, and A. L. Riker. While general mention can only be furnished here, therefore, of such work, something of its nature may be inferred from the account given by Mr. Leroy N. Scott in his book on "The Naval Consulting Board," and from the details of Mr. Edison's work alone.

At the very outset of his work on the Board, Mr. Edison put his business affairs entirely in charge of his officials, gave up his other experimental work and investigations at the West Orange Laboratory and devoted himself exclusively to this work for the Government and remained so engaged for about two years, spending much of his time in seclusion at Washington.



Views Covering the Electrical Side of the Great War

1—American Pole Line along a French Highway. 2—Wires in the Trenches. 3—A German Central Office in one of the Back Areas. 4—German Communication Office. 5—Field Station in War Zone. 6—Portable, Mounted, Telephone or Telegraph Station.

Mr. Edison gathered around him, as assistants, such young engineers as were at the time in his employ. He also obtained many volunteers from various colleges and universities, and he prevailed upon some industrial concerns to assign a few of their technical men to come to the laboratory and help along in the work. Besides these, Mr. Edison had about fifty skilled mechanics in his laboratory workshops, on whom he could call for making experimental apparatus.

The ideas and devices were developed almost entirely by experiment, and those mentioned relate to naval equipment or operations. A great many other experiments on different subjects were carried on but were not brought to a stage where definite reports could be made. It is said that considerably over 100 distinct lines of investigation were developed and followed up under the leadership of a man so well known for his unslacking energy in tracking the secrets of Nature to their inmost lair.

SPOTTING THE SUBMARINE

Submarine activity soon began to play havoc with shipping, and the problem of detecting the location of submarines by sound was considered one of the foremost problems of the day, and in a very short time it was recognized as being perhaps the most difficult one. Mr. Edison gave this problem a large part of his attention. He passed through many stages of employing telephones, audions, towing devices, resonators, etc., and in the summer and fall of 1917 had reached a fair degree of success in detecting sounds of torpedoes as far as 5,000 yards' distant. He became convinced that if he could install on a ship a device that should be arranged so that it would always be from ten to twenty feet ahead of the bow of the vessel, and if this device should carry a vibrating diaphragm, it would not have to contend with the noises of the ship itself (as these could be compensated for and made inaudible) nor with the noise occasioned by the rippling of water along the sides of the vessel, nor water-eddies affecting the acoustic apparatus. This device was afterward given practical tests in very rough seas, fulfilling all requirements, and was not in any way damaged or put out of commission, even in the roughest kind of cross-seas, with the vessel going at full speed, fourteen knots per hour. With this device, boats moving 1,700 yards away could readily be heard while the vessel was going full speed. A submarine bell five and one-half miles away also could be heard by the operator while a big storm was in progress and the boat also proceeding at full speed, and this with only plain diaphragms. There was no difficulty whatever in hearing a torpedo more than 4,000 yards away, and this is far beyond the effective distance at which a torpedo can be launched from a submarine. The noise made by a torpedo is very piercing and peculiarly distinctive.

In connection with the listening device on board ships, Edison desired to provide cargo-boats with a means of turning the ship very quickly to a right-angle course on hearing the launching of a torpedo by his listening device. His plan included the use of four sea-anchors each about nine feet in diameter at the mouth and each attached to a four-inch rope. The scheme was to fasten the ends of these ropes securely in the bow of the ship and to have the sea-anchors placed at the end of the ropes and midway of the ship. If the observer at the listening device reported a torpedo launched by a submarine at a distance, the signal was given and the four sea-anchors were immediately released and thrown overboard and the helm thrown hard over, bringing the ship almost to a standstill and turning her at right angles to her original course within a very short space of time and advancing only a short distance on her original course. In a test a loaded vessel 325 feet in length was turned 90 degrees from her course in two minutes, ten seconds, with an advance of but 200 feet, by the use of only four sea-anchors. Without the sea-anchors the ship made an advance of 1,000 feet in turning. It may here be mentioned incidentally that by no means keen on sailing the ocean blue, Edison did not hesitate to spend many hours and days afloat, subjecting himself willingly to fatigue, hardship and exposure, in his eager desire to "do his bit."

Prior to the time that Edison evolved

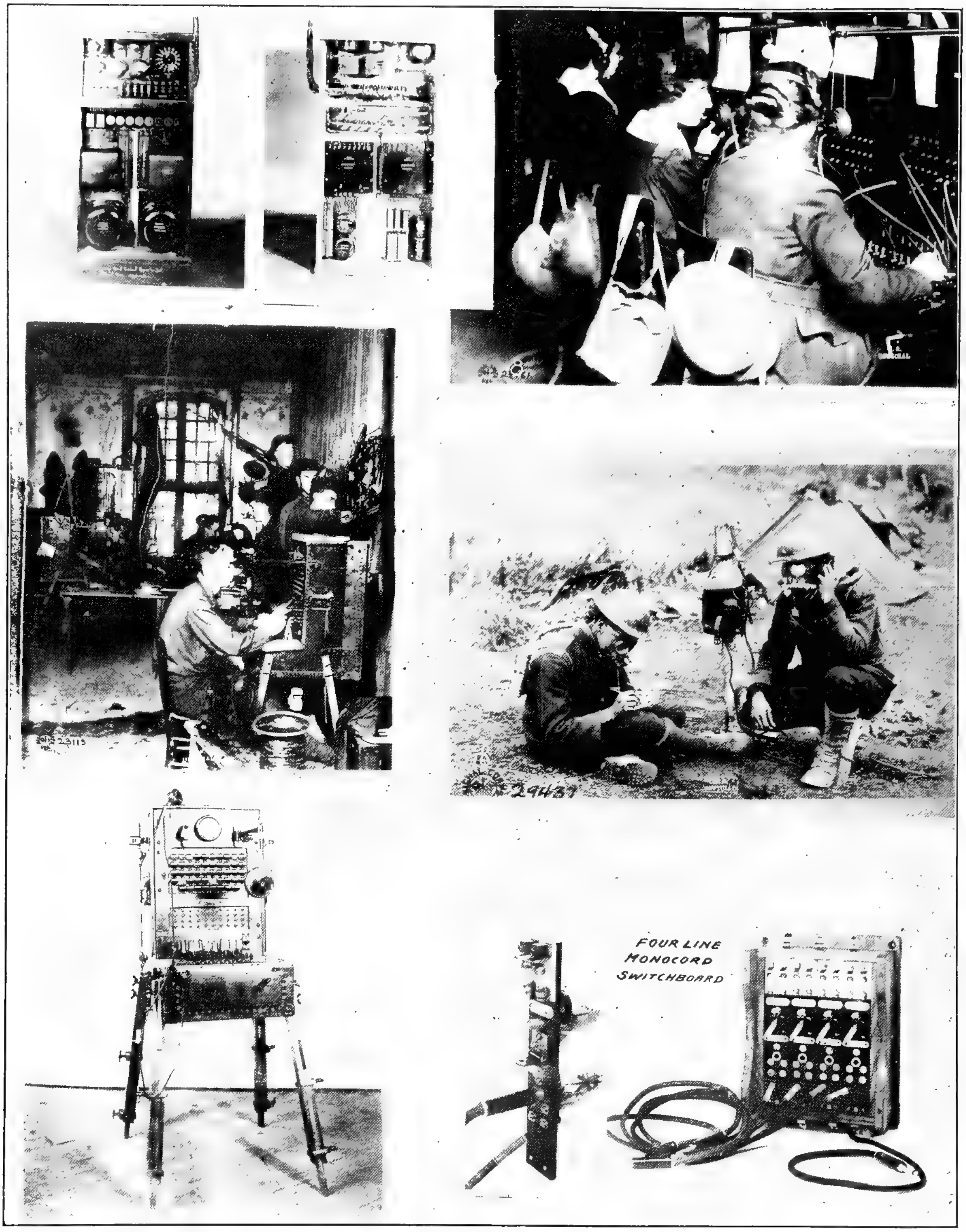
the idea of the quick turning of a ship, he experimented with a plan to enable merchant ships to escape torpedoes by the use of a gun, similar to a trench-mortar, from which should be fired an obstructive netting. This consisted of a small flotation tube, say, twenty-five feet long, over which is wound a net of one-foot mesh made of quarter-inch cable of very fine steel wires, the whole resembling a large window-shade. When the net strikes the water it unwinds and extends down twenty-five feet. If the torpedo were heard advancing toward the boat a large number of these nets would be thrown in its path, giving enough retardation so that it would be stopped or be so delayed as to miss the ship. In Edison's experiments he gained sufficient data to estimate that these nets could be delivered at least 950 feet from the boat.

Another of the problems was to provide a search-light to be used under water by submarines. After making a great number of experiments Edison found that the green line of barium in arc light penetrated salt water farther than any other observed. It was his impression that in blue water it might be possible to see an object 200 feet ahead with rather powerful apparatus, and he so reported to Washington, stating at the same time that he had reached a point where progress could not be made in the laboratory and that further experimenting should be done at sea. It may be added that his last experiments were with a sixty-foot tube filled with sea-water, at the end of which sufficient light was transmitted to read print.

It is well known that an ordinary projectile fired at sea will, on striking the water, ricochet and will not penetrate the water in a direct line so as to make a penetrative hit on a submerged target. During the height of enemy submarine activity, Edison also devised a type of projectile which would enter the water direct without ricochet, and would continue its course without deflection and make a penetrative hit. The various explosions on submarines resulting from an excessive accumulation of hydrogen gas rendered it highly desirable to develop a reliable and simple hydrogen detector. Edison therefore devoted some thought to this subject and after a series of experiments produced an accurate and simple instrument which would indicate as small a quantity as three one-hundredths of one per cent. of hydrogen in the atmosphere of a submarine. This instrument could be made in quantities for about fifty dollars. Information relative to this hydrogen detector was forwarded to Washington, but the instrument was deemed to be too fragile. However, Edison subsequently placed one of these instruments on a submarine used constantly for maneuver practice. It remanied on board nine months and was still all right at the end of that time.

In like manner a simple little device for use by lookout men in watching for periscopes in bright sunlight was suggested by Edison. It consisted of a tapering metallic box, open at both ends, fitted with a light-excluding eyepiece, and having diaphragms placed at intervals along its inside length. The device was painted a dead-black inside and out, and its construction was very cheap. In practice about seventy-five per cent. of the general glare would be cut off from the eye, allowing the pupil of the eye to dilate and making the vision much more sensitive. By the use of this device in full light of day objects could be discerned that were otherwise invisible.

The difficult problem of the determination of the location of hidden guns by observing the time intervals between which the sound of their discharge reached several known points was early undertaken by Edison. He had already performed a great many experiments with electromagnetic recorders in developing the telescribe, so that he was able to utilize the instruments developed in this study for the recording of gun-sounds. It was found that the phonograph method of recording had peculiar advantages for this work. Edison's constant endeavor was to keep the length of the base-line short, and therefore his efforts were to keep the chance of error as low as possible in all his apparatus. Actual tests made with modern guns showed that under varying weather conditions the position of an unknown sound could be located within two per cent., plus or minus, of the measured distance, with a base-line not exceeding one-sixth of the range distance. Under favorable con-



Signal Service Telephone Work in the Great War

7—Front and Back Views of a Standard Telephone Repeater Amplifier. 8—Central Office Operated by American Girls. 9—Portable Camp Switchboard with Operator Plugging In. 10—Hand Set with Magneto Box out in the Field. 11—Showing the Switchboard used in Figure 9. 12—Monocord Type of Switchboard—an Invention of the War.

ditions some remarkably close results were obtained. With a base-line 1,800 feet long (the longest base-line used) the gun could be located over two and one-half miles away, within a foot or two of the actual position. When records had been obtained on a particular type of gun for study, it could usually be identified by a trained observer from guns of other caliber.

Another of the problems submitted was to find some method of preserving submarine guns from rust. Edison made a large number of experiments and finally found that if extra fine zinc-dust is mixed with vaseline and smeared over the gun no rust whatever formed, either in air, or sprayed with sea water, or wholly immersed in fresh or sea water. If only plain vaseline was used the polished steel became badly rusted. These experiments were conducted for several months in air, also with metal submerged in fresh water and sea water, with entirely successful results.

It readily will be understood that Mr. Edison was not the only student of these and other problems of the kind, but the above brief account of some of his work is interesting to say the least and typical of the zeal with which supreme inventive ability and minds trained theretofore only to deal with the problems of peace and industry were diverted to the vital military problems of colossal warfare and destruction. It also serves to exemplify the special problems of the Navy and how they were dealt with.

ELECTRICITY IN THE ARMY DURING THE WAR

In turning to the use of electricity by the Army in the Great War, we find this summed up naturally and fitly in the work of the U. S. Signal Corps and in the monumental report of the Chief Signal Officer, Major-General George O. Squier for 1919 to the Secretary of War—a profusely illustrated volume of nearly 600 pages. It is literally impossible for reasons of space to deal with such a report adequately in a few pages of this "Story of Electricity," but it will be interesting and instructive to glance at the "high spots" of the official narrative, in introducing which General Squier remarked—"The importance of intercommunication in warfare cannot well be exaggerated. The element of time is a controlling one in strategy and tactics, and as the distance becomes greater the electrical method of intercommunication surpasses all others in increasing ratio. Unity of command, which the Allies were so slow in realizing, can reach its full value only when the most perfect system of intercommunication is established and maintained between general headquarters and the larger units, and between these and the smaller units, to the man on the firing line."

In view of this brief statement as to the vital importance of a perfectly functioning nervous system of the Army, let it be borne in mind that the United States which put an army of 4,000,000 men into the field had a Signal Corps on April 6, 1917, of only 55 officers and 1,570 men, and as it averages from 2½ to 4 per cent. of the army personnel it will be obvious that instead of 1600 officers and men the corps needed suddenly some 80,000. The problem therefore was to secure the very best trained men in this country from the telegraph, telephone and electrical manufacturing industries for service after our entry into the war, as part of the American Expeditionary Force. General Squier took the question up immediately with President Theodore N. Vail of the American Telephone and Telegraph Company and President Newcomb Carlton of the Western Union Telegraph Company, as well as with other leaders in these fields. The first move was the commissioning of some of the leading executives and engineers of such companies, and these in turn were charged with the selection and organization of the trained personnel to be sent abroad immediately to start the work needed to be done while the new American Expeditionary Force could be trained in this country.

During the early months of the war, therefore, these officers in the uniform of their country, installed in their regular offices, with the full machinery at their disposal, represented for a time the United States Army as well as their former employers, and through the hearty coopera-

tion and loyal support of all hands the Signal Corps was enabled to get under way with the ablest and most experienced technical men in the country in the shortest possible time. As a result of this policy the Chief Signal Officer of the Army secured the services, as commissioned officers in the Signal Corps, of J. J. Carty (Col. D. S. M.), chief engineer of the American Telephone & Telegraph Co.; Dr. Frank B. Jewett, chief engineer of the Western Electric Co.; Charles P. Bruch, vice president of the Postal Telegraph Co.; G. M. Yorke, vice president of the Western Union Telegraph Co.; Dr. Robert A. Millikan, professor of physics at Chicago University; all of whom rendered valuable service in connection with the technical work of the corps. As a further result of this policy of cooperation with the great industries of this country interested in work identical with that of the Signal Corps, the American Telephone & Telegraph Co., as well as the association of independent telephone companies, took immediate steps in cooperation with the Chief Signal Officer of the Army toward the organization of reserve Signal troops under the provisions of existing law. This action of the Bell Telephone system organizations alone made possible the organization of 12 battalions of highly trained technical men ready for immediate service overseas. In the meantime, of course, the machinery for a large number of technical schools was set in motion which later produced the flow of field and telegraph battalions required for Signal Corps service with the combatant troops on the firing line or back of it.

By the time of the close of the war, the U. S. Signal Corps had built a huge telegraph and telephone system in France which included about 3500 kilometers of pole line carrying 50,000 kilometers of copper circuit. Including 120,000 kilometers for telephone service between the various headquarters and the front, the system connecting also Paris with London, comprised a total of not less than 358,500 kilometers of wire in France and England, and extending at last into the occupied regions in Germany. It is doubtful whether there is any exact record of the telephone messages interchanged, but it is estimated that the telegraph service carried an average of 10,000 telegrams of say 60 words each, or 600,000 words, a day. The highest record was 47,500 telegrams or 2,850,000 words in a day; and the total service given up to the time of the armistice is put at 5,000,000 telegraph messages over circuits carrying telephone messages as well. The trunk lines from Paris to General Headquarters at Chaumont of four aerial parallel copper circuits carried twelve telegrams, six each way, and with the aid of a phantom circuit, furnished facilities for three sets of telephone communications at the same time without confusion or interruption. The army telephone exchanges numbered no fewer than 257 at the fateful date of November 11, 1918; the first telephone exchange for internal and external service having been set up by the Signal Corps in Paris in June, 1917. Unavoidably there were linguistic difficulties in spite of liaison officers, and resort was had to the efficient aid of women operators enlisted through the American Telephone and Telegraph Company in America, who as soon as trained were attached to the Signal Corps and were sent overseas in units and located in a number of French centres. More than 450 girls undertook the training course and 223 of them were sent abroad. Each operator wore a distinctive dark blue uniform, with chevrons on the arms, of a telephone transmitter, an appropriate hat, etc. The statement has been made, and seems to be quite authentic, that Marshal Foch during many trying days along the Allied front sought out at many critical moments the nearest Signal Corps telephone exchange and used it freely in communicating with the various commanders of the respective Army Corps and of the chiefs of the great armies under his direction as allied Commander-in-Chief. The dangers and the losses in personnel of the Service may be inferred from the recorded fact that at one time a short stretch of telephone line under shell fire near Soissons, had 350 breaks in only one kilometer length.

General Squier in his report records that the Corps reached a total of 2712 officers and 53,277 men and he quotes a tribute from Gen. Pershing, as Command-

Novel Features of Field Telephony in the Great War

13—Non-interferable "Buzzerphone," Product of the War, to Permit Secret Messages. 14—Aviator's Telephone Apparatus with Both Units in Same Box. 15—Submarine Detecting Apparatus. 16—Wind-Driven Generator to Produce Current for Aviator's Radio Telephone. 17—Airplane Detecting Apparatus. 18—Detecting Apparatus for Coast Defense. 19—Two-Place Airplane. Both Men Equipped with Wireless Apparatus. 20—Transmitter and Receiver for Airplane Talking. 21—Gasolene Can Used as a Detector—Close to the Front. 22—Receiving Tube for Radio Telephones. 23—Three-Stage Amplifier Increasing Energy a Million Fold. 24—Transmitting Vacuum Tube for Radio Telephones.

er-in-Chief of the American Expeditionary Force, under date of February 19, 1919, as follows: "Now that active operations have ceased, I desire to congratulate the officers and men of the Signal Corps in France on their work, which stands out as one of the great accomplishments of the American Expeditionary Forces—the result of a happy combination of wise planning and bold execution with the splendid technical qualities of thousands of men from the great commercial telephone, telegraph, and electrical enterprises of America. It is a striking example of the wisdom of placing highly skilled, technical men in the places where their experience and skill will count the most.

"Each Army corps and division has had its full quota of field signal battalions which, in spite of serious losses in battle, accomplished their work, and it is not too much to say that without their faithful and brilliant efforts and the communications which they installed, operated, and maintained the successes of our armies would not have been achieved.

"While the able management of the directing personnel is recognized, it is my desire that all members of the Signal Corps, who, regardless of long hours and trying conditions of service, have operated and maintained the lines, shall know that their loyalty, faithfulness, and painstaking care has been known and appreciated. In the name of the American Expeditionary Forces I thank them one and all and send to them the appreciation of their comrades in arms and their commander-in-chief."

The Squier report speaks of the Signal Corps equipment for the war as "beyond what anyone could have dreamed." For instance, a single order for a certain kind of insulated wire was in sufficient amount to extend fourteen times around the earth. The cost of needed field glasses was over $40,000,000, and wrist-watches for Signal Corps operators ran to a total of 43,000. Over 1,000,000 cells of battery were produced for the work, and 285,000 vacuum tubes of novel type were required for radio amplifiers; and more than 8000 sets of one type of radio apparatus were prepared and shipped to France. More than 100,000 telephones were necessary, and over 200,000 pliers cut and twisted wire in line construction work. These are but one or two of the 267 items furnished to the various branches of the Army as unit equipment; but in addition more than 2000 items were called for by the special services and in maintaining communication in the zone of supply. Moreover, scarcely a single piece of technical apparatus that was regarded as adequate at the beginning of the war was to be found in the Signal Corps equipment at the time of the signing of the armistice. Strong research departments were founded both in France and in the United States and the best men of the country available were assigned to this work. Many of these men were taken from universities and colleges; and electrical, chemical, physiological and mechanical specialists were set to work on both sides of the Atlantic to devise new means of supplementing the methods of signaling and associated subjects. In engineering development the demands grew to the proportion of a large industrial plant. A large part of the facilities of the Bureau of Standards was requisitioned on a large number of special problems and the principal personnel of the Weather Bureau were used in the newly established meteorological service.

It was soon realized that a special laboratory devoted exclusively to development work, and entirely independent of the commercial laboratories, such as the Western Electric Co. and the General Electric Co., would be needed, and a special laboratory fully equipped for radio development was established at Little Silver, N. J., which grew to be one of the largest in the world. This site was later recommended for purchase for the permanent use of the Signal Corps and the experience of the late war has clearly shown the necessity for an institution of this sort where trained specialists may devote their entire energies to the new problems constantly arising in the extension of methods of intercommunication now appearing as never before. To handle efficiently much of this new and novel apparatus, moreover, required help from special schools at the leading seats of learning and technical schools, as well as at five large training camps; viz, Camp S. F. B. Morse, Camp

Alfred Vail, Franklin Cantonment, Fort Leavenworth and, lastly, College Park, Md.

It will be noted that a large number of vacuum tubes were required; but the mere number tells only half the story, for these tubes are ordinarily a very delicate piece of apparatus, and now they had to withstand all kinds of perils in shipment and hardships in use for radio work; as well as to be designed for sending and receiving, as well as for other accessory purposes. After describing the "incandescent grid" vacuum tube as an appliance, Dr. A. E. Kennelly remarks in *The New World of Science* that the capabilities of these tubes are amazing. "A series of them is frequently used as a multiple amplifier in receiving and magnifying very faint radio signals. Each tube may successively multiply the strength of the received signal say ten times. A two-tube system can then amplify 100 times and a three-tube system 1000 times. Amplifiers of as many as 20 tubes have been occasionally used, and 7-tube amplifiers are common; but the available ratio of amplification is not so high, when so long a succession is employed."

Aeroplane work made many new demands as soon as signalling between the ground and the plane ceased to be merely visual, and became telephonic. One of the new devices for the airplane radio set was a special little dynamo machine of the windmill type carried under the fuselage, driven by the motion of the plane through the air, and required to rotate at a nearly constant speed over a wide range of airplane velocity.

It is obvious that a voice-commanded squadron of planes becomes a novel and very important fighting unit; but, here again were new difficulties. Dr. Frank B. Jewett (Lt. Col. U. S. Signal Corps, A. E. F.) chief engineer of the Western Electric Company, thus describes the big problem to be solved in such work; "In the first place you had to get a receiver through which you could hear the radio speech, and which would at the same time cut out the noise of the engine. That problem was solved without making any particular change in the type of receiver used. It was essentially the watch-case type of receiver. It was a problem of acoustical shielding. The transmitter had to be operated effectively by the voice of the observer talking in a low tone, and at the same time shut out disturbances due to the unmuffled exhaust of the engine. The problem was solved by shielding the diaphragm of the transmitter with a very thick shield through which a few pin holes were punched. The result was that when you talked directly at the instrument, the instrument was actuated; but if the sound came from even a slight angle, it never got into the diaphragm. Consequently you could talk perfectly into this transmitter in a place where you absolutely could not hear yourself shout, and yet you would hear none of the noise which made it impossible for you to hear if you didn't listen through a receiver of this general type." Akin to this work was that of adapting the radio telephone to submarine work, for the destroyers and "sub chasers," getting away from the early apparatus which required the sub chasers to "stop, look and listen" and enabling them instead to talk back and forth, maneuver in an instant as a unit, or act individually over a new and separate course. Admiral Sims tells in an article in the *World's Work* (March, 1920) of a sub chaser listening for hours for some movement of a wounded enemy submarine—and then hearing twenty-five pistol shots in quick succession from that submerged coffin of steel!

That the German submarines while operating off the Atlantic coast during the war succeeded in accomplishing part of a supposed gigantic Central Powers plot to cut all cables and destroy all high-power radio stations on the American coast is practically proved in the annual report of Major-General Squier, in which he deals with the reputed plot. The army was informed of the plan by the navy, whose information was from sources considered reliable; and he also deals with the partial accomplishment which was effected when two submarine cables were cut on May 28, 1918, about 100 miles from New York. The New York-Canso, Nova Scotia, cable failed to function at 12:35 P. M. on May 28. The other, from New York to Colon, Isthmus of Panama, commenced to fail at 3:30 P. M. on the same date, and went out

of service at 9:30 P. M. The two cables were soon repaired, but their continued inactivity would have hampered but slightly transatlantic communication, the report declares, because only one was used in the transatlantic service, and that merely as far as Newfoundland.

The evidence which led John J. Carty (vice president and chief engineer of the American Telephone and Telegraph Company), then a colonel in the Signal Corps of the Army, and other cable experts to assign the guilt to German submarines was the fact that German submarines were operating along the Atlantic coast at that time, and further that the severed section of each cable was studied by Colonel Carty and other cable experts, according to the report, which explains that their examination disclosed that the cables were cut and not merely worn out or damaged by ordinary causes. "The points at which the armored wires were severed in both cables showed clearly the evidence of a sharp cutting tool, and the absence of rust on the ends of the armor showed that the cut was of recent origin," the experts reported.

A few months after the United States entered the war Col. Edgar Russel, later Brigadier-General and Chief Signal Officer of the American Expeditionary Forces, investigated the reliability of cables between the United States and Europe. Shortly before he sailed for France, in August, 1917, at a conference held with Colonel Carty and other cable experts in New York, it was concluded that complete severance of the cable by the enemy was not impossible.

The navy reported early in May, 1918, that "the enemy was using submarine vessels to cut cables and that certain local European cables had already been severed, presumably by this means." In June, 1918, the navy said it had heard "from sources believed to be reliable that the Central Powers were making preparations to cut all cables on the American coast by specially constructed submarines, and also to destroy all high-power American wireless stations. If unsuccessful, the enemy intended to make wireless communication difficult by elaborate means of interference from German wireless stations with messages coming from and going to American high-power radio stations."

Before the navy warnings and the partial fulfilment of the prophecy, General Squier, as a result of the opinions of Colonel Russel, Colonel Carty and other cable experts, directed Colonel Carty to take the necessary steps to develop the radio-telegraphic communications between the United States and Europe in order that communication between the War Department and the Commander of the American Expeditionary Forces would not be destroyed if the Central Powers succeeded in severing the cables. The report discloses that through the cooperation of the army and navy an efficient radio-telegraphic communciation service between the United States and Europe was effected by developing to the greatest practicable extent the high-power radio stations on the Atlantic Coast, which worked in conjunction with the high-power radio stations in Great Britain and Ireland, in France and Italy; and some in Canada also were utilized. The Navy Department completed as soon as possible the high-power station it was building at Annapolis. The navy designed and erected another station in France, near Bordeaux.

General Squier sums up his impressive and fascinating narrative of work in the Great War with remarks bearing upon conditions of the moment, over two years later, and prophetic as to what "The Story of Electricity" may be in the future in regard to the problem of world communication:

"The day I believe is not far distant, when we can reach the ultimate goal so that any individual anywhere on earth will be able to communicate directly by the spoken word to any other individual wherever he may be.

"Nor is this linking up of methods of communication restricted to the surface of the earth. To a limited extent, we can communicate from points above the earth to points beneath the surface of the earth or of the ocean. To-day we are talking directly from the high-speed airplanes above the clouds to the wire systems of the country, and ships at sea also can speak from midocean to land stations of the wire system.

"It is possible, for instance, for the President of the United States to exercise his functions during residence in Europe, which would have been utterly out of the question a few years ago. Indeed, the time is not far distant, it is believed, when the President of the United States may address from the White House practically the entire American people assembled in their respective localities throughout the country to receive his message by his own voice.

"The radio lighthouses, which shall mark the aërial highways throughout the land, and serve as beacons for the guidance and location of aircraft on every voyage, are an accomplished fact, and these will multiply rapidly as each city and town of the country is brought within the expanding network of public and municipal flying grounds.

"These lighthouses have certain advantages over the normal lighthouse in that their ranges may be much greater, and they are not invisible in the daytime nor obscured by fog and mist. Surely no development can surpass in wonder and amazement the accomplishments of radio telephony and telegraphy and certain associated subjects now being realized every hour.

"We are on the threshold of the inauguration of what is called the League of Nations, and drastic limitations to the enormous burdens which nations in the past have carried in the creation and maintenance of military armaments will, it is hoped, be imposed. The practical execution of the provisions of the League of Nations from the military, economical, social and diplomatic standpoints will depend, it is believed, very largely upon the creation, expansion, and maintenance of the most perfect interlinked network of inter-communication, literally covering the land, sea, and air. Such a perfect system will be the cheapest and most certain adjunct to effectively carry out the provisions of this league, and will contribute to a better understanding between the various nations as will no other agency or instrumentality."

CHAPTER VI

THE STORY OF ELECTRICITY AS THE ANGEL IN THE HOUSE *

"A Turkey is to be killed for our dinner by the Electric Shock and roasted by the Electric Jack before a fire kindled by the Electric Bottle, where the healths of all the famous electricians of England, Holland, France and Germany are to be drunk in Electrified Bumpers under a discharge of guns from the Electric Battery."

Such was the brilliant and startling suggestion of that great American genius, Benjamin Franklin, for an Electrical Dinner, in the year 1747. Thus nearly two hundred years ago did the sage of Philadelphia outline the very latest applications of electricity to the service of the American home and the needs of domestic life. Limited as was electrical science in his time—so long before the days of Volta and Faraday even—Franklin with the vivid prescience of a real prophet, envisaged the practical uses of the protean agent which through coming years was "to make all things new." The passage quoted may well afford a text for the little discussion in the present chapter of the marvellous development and the innumerable appliances associated with the utilization of electricity by ten million American families in the Twentieth Century.

It is not proposed in this chapter to dwell upon the domestic use of the telephone and the electric light, except in a casual way. They are part of the "story," and it is impossible to present a picture of modern electrified social life in America without reference to them. But they have been an element of recognized domestic economy and organization so long that the period since 1900 has in reality no new features to present of serious significance in this field. It has only been a matter of intensification—of growing "saturation."

Before going into the detailed consideration of the subject, it may be well to inquire just how far "electrification" has gone in the United States in connection with the use of electric light, heat and power. At the end of 1919, the central stations of the country covered territory, or areas, populated by 62,023,400 people—out of a population now known to be a little in excess of 105,000,000. Of this population within reach of central station service about 55.8 per cent lived in electrically lighted houses. There were reported 6,291,160 houses wired for electricity in such territory, and in some states, with cheap hydro-electric energy like California, the percentage of houses wired had already reached the possible limit, while it was low in states of minimum electrical plant development, like Mississippi. The total number of retail stores wired was put at 1,459,169, and the number of farm lighting plants, beyond the reach of central station circuit, was no fewer than 340,000. These interesting figures have been susceptible of confirmation from various sources. The U. S. Census Office reported that in 1917 the central stations of the U. S. A. had no fewer than 7,178,103 customers. The estimated number in 1920 is put at 8,520,400. Just how many of these were domestic is not known

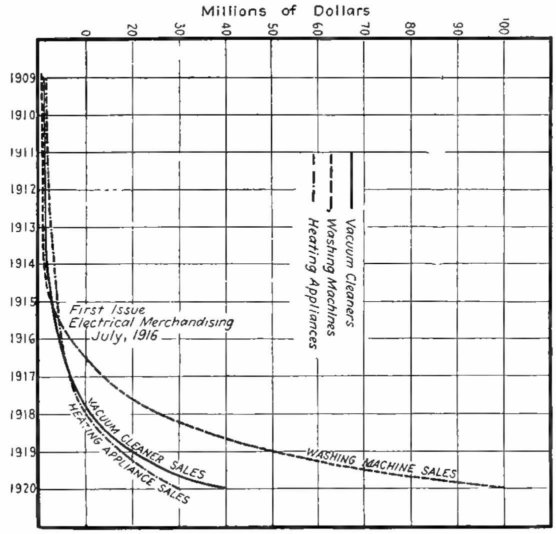
* Text prepared in 1920.

definitely; but it may be noted that the statistical department of one of the great electrical manufacturing companies estimated from its careful survey that on Jan. 1, 1918, there were 5,000,000 wired houses in the country. Since the general growth in customers of all classes from 1914 to 1920 was 81 per cent for the six years, it would seem altogether conservative to put, as has been done above, the number of American homes enjoying electricity for domestic service by not later than 1925 at 10,000,000 or more. All the figures entering into such an estimate are consistent and justifying, especially in view of various facts and data not generally known but bearing very pertinently on the problems of American domestic life.

The population of the U. S. A. has been officially declared at about 105,000,000, which shows an increase for the decade 1910-1920 at the rate of 14.2 per cent. But the striking fact is that this is less than half the rate of increase of the decade 1870-1880. Forty years ago, the population of the U. S. A. was just half what it was in 1920, being a little in excess of 50,000,000 in 1880; but the rate of increase from 1870 was 30.1 as compared with the present rate of 14.2. Now this may fairly be attributed to the decline in immigration during the latter period, and particularly during its second half, coinciding closely with the term of the great "World War"—namely 1914-1919. In the five years ended with the fiscal year of 1919 our immigrant total was only 1,172,679 as against 5,174,661 in the preceding five years. Allowance for this difference of 4,000,000 would bring the actual growth of the decade 1910-1920 of 13,000,000 up to say 17,000,000 which would compare very favorably with the growth or rate of growth in any previous decade. Moreover there was the decline in population due to the fact that during the war period 1914-19, many hundreds of thousands of immigrants still unnaturalized were recalled to fight under their old national colors. Since the armistice, this has been paralleled by the exodus of another larger contingent of Europeans cut off for five years from intercourse with their relatives abroad and eager, for creditable domestic reasons, to return if only for a short time to their countries of origin. In 1920, this ebbing tide gave evidence of reflux, and emigration to America had more than resumed its wonted large proportions.

It is said 3,000,000 Italians alone awaited eagerly the opportunity to leave for America. But in the meantime, the effect on the statistics of population was seen—bringing with it two results—the great scarcity of labor of all kinds and the higher cost of living.

These two conditions are, it is true, not peculiar to the United States. The parties to the World War had armies aggregating 30,000,000 and war casualties of 9,829,000; the decline in births per year in the ten leading European countries was 20,000,000; and the national debts of the world rose from 40 billions of dollars to 265 billions with an interest charge of 9 billions per annum, or $6 per capita as against $1 per capita in 1913. All these are startling and terrible figures as bearing upon the real reasons for the present scarcity and dearness of labor, and the likelihood of the continuation of such conditions. Out of these conditions and data emerge the fact, so sadly familiar, that the cost of living in America has gone up at least 104.5 per cent in 6 years, while



Curves Illustrative of Increase in Sales of Electric Domestic Merchandise.

the rise is put by the Industrial Conference Survey at not less than 119 per cent in food, and 166 per cent in clothing, etc. Confronted by such statistics and the grim realities of existence into which they are translated, the American householder and housewife have found a swift and satisfactory solution of new problems presented, by resort to domestic electric devices and appliances. The interrelationship of all these facts and phenomena has been reduced to a chart which is here given and which is probably new to most of those who now see it. The curves in the chart show the extraordinary manner in which the decline in the immigration of women into this country is associated with and reflected in the contrary enormous increase in the number of three leading classes of domestic electric conveniences during the past ten years. Rarely has so significant a set of curves bearing on social-economic conditions been presented for study. As in the art of aviation, it may be said with regard to domestic electric service, that the Great War caused more advance in five years than would have been effected in fifty; and there is, moreover, the corollary or inevitably attendant proposition that such progress once achieved is never lost. On the contrary the gains and advances will be accelerated. In the electrical field it is a well-known fact that during the distressful period of war 1914-1919, the demand for electrical energy for the production of munitions and other war-like material was so great, that its use for mere pacific industrial or domestic purposes was severely rationed. All the "priority orders" ran counter to domestic use, and the central station was rare indeed that did not either curtail the activities of its "commercial" department or abandon entirely the customary efforts to "hook up" new customers. Added to this is the outstanding condition that few new houses were built durthe Great War and that every urban center in America, if not the world at large, is confronted with a housing problem and a serious shortage of homes. In the creation of these hundreds of thousands of new homes, for which the supply of domestic help is relatively smaller than ever before, the dominance of electricity, or deliverance through its aid, is at once apparent. As has been said rather cleverly:—"Electricity has got into the bourgeoisie. It has at last arrived in the class of which middle class unions are made. Like religion it started out with the proletariat. The garment trade workers were the first New Yorkers to adopt the electric flatiron by acclamation. The Middle West farm wife, 'the woman whom God forgot,' discovered the washing machine almost immediately after Mr. Shipping Board Hurley did his share in developing it."

Which is amusingly put, but hardly exact enough for the historical part of a "Story of Electricity." The little electric fan now so ubiquitous has been with us since the earliest days of the incandescent light, and an article by one of the editors of this "Story," remarked as long ago as 1892*: "There has sprung up a wish everywhere to enjoy the benefits of electric power for ventilation, pumping water, domestic elevators and the like until at last the electrical engineer sees before him a range of work that is still unfamiliar and that involves not a few problems." Some interesting illustrations of what could even then be done were given, and it might be fairly said that the intervening years have been devoted quite largely to the refinement and perfection of primitive forms of early apparatus, some of which persists even to the present day, but which could not have been made universal if unceasing ingenuity and untiring inventive ability had not been addressed to them. Thus the contributor to one of the electrical journals stated recently that he had a three-heat hot-plate which bore on it the date, May 8, 1899, and had thus been in use for twenty years, without any cost for repairs, and which using current in no fewer than thirty-two States, had been in service for about 10,000 hours using at an average rate of 10 cents per kilowatt hour not less than 1650 kw. hours of electricity worth $165. It is in such an illustration of the general simplicity, strength and reliability of domestic electric apparatus that the reasons are found for its growing popularity. The pregnant suggestion has been made

* "Electricity in a Modern New York House," by T. C. Martin, *Electrical Engineer,* May 25, 1892.

that whereas the introduction of steam was the cause of the decay of almost all the old domestic industries carried on in the home, the introduction of electricity into the modern home may bring back such individualized industry and put an end to many of the evils of the prevalent factory system. Be this as it may, the conclusion may happily be reached that at least in the availability of simple electrical appliances for the home, and a centralized source of cheap current supply, lies the preservation of the separate, sacred home as against its abandonment for dismal herding into hotels or the promiscuous existence found in gregarious communism.

Before passing on to deal with the economic conditions involved in the change to electricity, a brief summary or list may be made of the leading electrical domestic appliances on the market such as any good supply house may be expected to carry in stock. This list includes the following:—Primary and storage batteries; candelabras and electric "candles," curling irons; bells and bell transformers; casseroles; chafing dishes, coffee pots, urns and grinders, disc stoves, washers, and appliances for disc cooking, drink mixers, electric ovens, fans, fireless cookers, footwarmers, floor scrubbing and polishing machines, garage heaters, glue pots, grills, hair dryers, heating pads, hot plates, hot water pots, kettles and urns, immersion heaters for bath tubs, shaving cups, etc., ice cream mixers and freezers, irons for curling and marceling purposes, laundry irons, mangles, milk warmers, ovenettes, oyster fryers, percolators, plate warmers, portable drills and other like tools, room heaters, refrigerators and cooling or iceing appliances, samovars, sewing machines, serving dishes, sealing wax heaters, sterilizers, soldering irons, travelers' irons, electric toys, trains, ranges, etc., toasters, toasting stoves, tea pots and urns, vibrators, violet ray outfits, vulcanizers, vacuum cleaners, water urns, waffle irons, washing machines, Christmas tree outfits, electric kitchen ranges.

Long and varied as this list may seem it is not by any means complete as a catalogue of available electric domestic appliances, nor does it reveal the scope of their use. The statement has been made authentically that no less than $175,000,000 was spent by the American public in 1919 for electrical devices to be used in the home. The output of smaller motor driven devices for 1920 is estimated at 2,000,000. The manufacturer of a vibrator for hygienic purposes stated that he was 182,000 behind his orders. The output of electric vacuum cleaners is said to have risen from 100,000 in 1916 to 750,000 by 1919, and of washing machines from 150,000 in 1916 to 475,000 in 1919. It was stated not long ago that whereas there were only 10,000 electric ranges in use in the United States in 1915, the number would reach no fewer than 500,000 by 1922, and that during the year, by conservative estimate a possible market was ready for another 100,000, although whether that number could actually be sold depended not on the demand but upon the ability of the central stations of the country to finance the additional investment required on their part in the circuits, transmission lines, and transformer capacity. It is also worthy of note that the market for this class of apparatus lay almost entirely in the Pacific Coast region, and the Middle West, and that the Eastern States had so far done little to foster the introduction of this novel and useful apparatus.

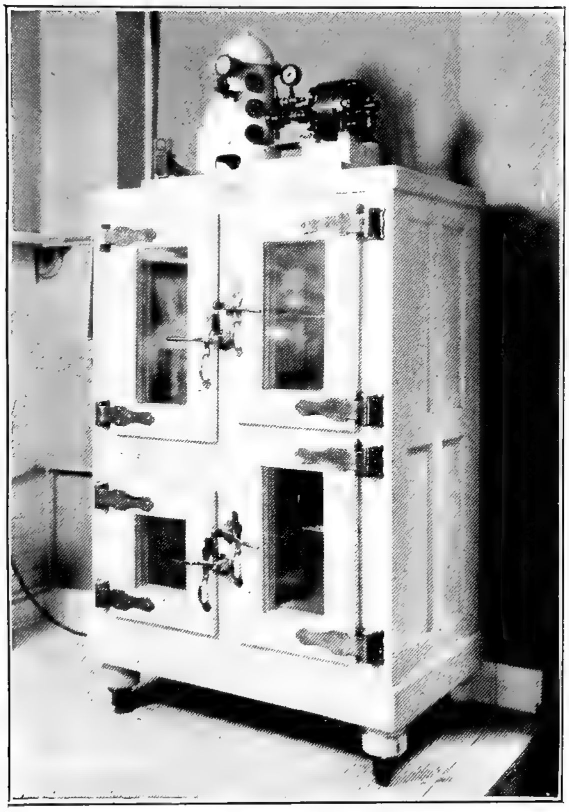
The popularity of all such devices depends on its economy of time, labor, material and money; and each of these essential factors in the problem is controlled or determined by many others. The cost of the apparatus is one of these conditions; the cost of current is another; the availability of domestic help is a third vital item. A most interesting analysis and study of the principles and results of electrical equipment and utilization was presented some months ago by Mary Ormsbee Whitton in *House and Garden,* under the apt title of "The Eight-Hour Kitchen." A few of the salient points may here be noted. Thus, for example, she states that in a series of extremely careful tests made by arrangement with a group of domestic scientists and a large electric lighting company, it was found that a family of three persons could have three average meals per day prepared on an electric range at a cost of 2.01 cents per meal per person;

that for a family of five it fell to 1.29 cents, and for a family of eight the current consumed cost .957 cent per meal per person, at the rate for electrical energy prevailing in New York City where all the development of electricity is based on coal brought a long distance from the mines. Electrical domestic apparatus is far more generally used where the cheap current supply is based on water power.

Then comes the question of time saving, which is involved whether you have a maid or perforce go without help. Mrs. Whitton states that in a family of four people, "cleaning up" by hand requires more than fifteen hours a week as against twenty-four hours for the preparation and cooking of food. She adds that by the use of suitable electrical devices, all within the reach of persons of moderate means, the preparation and serving of food is brought down to eighteen hours a week and "washing up" to ten hours. Of course the time saving varies with the number of persons to be provided for, but it is stated that for a family of moderate size a clear economy of nineteen hours per week is effected, or nearly 2½ working days on an eight-hour day basis. Need it be wondered that in the electrified home the "slavey" is no longer needed, and that the "mistress of all work" can still find plenty of leisure for social engagements and recreation? The data furnished by Mrs. Whitton are confirmed from another angle by Mr. John R. McMahon in an article on "Making

All-Electric Kitchen Outfit. Includes an Electric Range, Fireless Cooker, Percolator, Grill, Ovenette, Vacuum Cleaner, and Ironing Machine

Housekeeping Automatic" in the *Ladies' Home Journal* for September, 1920. He is a little more elaborate in his figures and may be quoted thus: "Our chart itemizes the difference in weekly hours of labor with or without machinery as follows: Breakfasts, 7 hours against 10 hours; luncheons, 10½ hours against 14; dinners, 10 hours against 12; dishwashing and clearing, 10½ hours against 15¼ hours; washing and



Electric Refrigerator with Ice-Making Section—Produces Sherbets, Frozen Desserts, Mousses, etc., in Addition to Refrigerating.

ironing, 6½ hours against 9 hours; marketing and errands, 6 hours in either case; sewing and mending 3½ hours against 4 hours; bedmaking, 2¼ hours against 3½ hours; cleaning and dusting, 2 hours against 3 hours; cleaning kitchen and refrigerator, 2 hours in either case; which shows a total of 18½ hours' gain for rest and recreation."

It need not be wondered at, as has just been said, that the new electrical era in domestic life is being marked by many new departures, in a cumulative manner, so that during the summer of 1920 one real estate company operating in the vicinity of San Francisco announced that all its residences hereafter would be built as "electrical homes," equipped with all that the phrase implies. It was stated that at the same time 150 houses then under construction at Oakland, the beautiful suburban city on San Francisco Bay, would be wired for electric ranges. But the other day, it was similarly a novel appeal to pipe a house for a gas range. The next step in these "electrical homes" is to wire and equip for electrical refrigeration. Amongst the most attractive exhibits at the New York Electrical Exposition of late were those providing for electrical refrigeration and wholly eliminating the ice man. Broadly described the domestic refrigerating machine is designed to maintain the average household icebox or refrigerator at a much lower temperature than can be obtained with ice—when you can get the ice—and at the same time keep the air in the refrigerator at a uniform temperature and dry. In a paper before the Indiana Electric Light Association in March, 1920, Mr. Robert Montgomery, of the Louisville, Ky., Electric Company, emphasized the great value to the householder of such apparatus and said: "We have a machine (brine circulating) in our model kitchen which has been in operation since October 1, 1919. The machine has a capacity of 30 cubic feet, and is being operated in connection with a refrigerator having a capacity of 17 cubic feet. This oversize machine was installed for the reason that the doors of the refrigerator are opened and closed continuously all day, on account of frequent demonstrations. The machine has operated continuously since October 1, and has required no adjustments whatever, nor any attention other than an occasional oiling. Since the machine was installed it has consumed an average of 100 kw. hrs per month" Mr. Montgomery further says: "The average family that is able to purchase a refrigerating machine is using not less than $4 worth of ice per month. The cost of ice for one domestic consumer before purchasing a refrigerating machine averaged

$10.25 per month for the previous twelve months. The retail price of ice in Louisville is 50 cents per 100 pounds." An endless vista of new convenience opens up with the introduction of this new appli-

Electric Kitchen Motor. Attachments with this include Ice Cream Freezer, Vegetable Slicer, Meat Chopper, Strainer, etc.

ance, with again many social and economic readjustments. So far as the central stations are concerned, it may be pointed out that here is a "load" that need not interfere with any daylight service, but can comfortably and cheaply be taken care of in the idle hours of the night when only street lighting demands current, and the machinery of social and industrial life is at the level of minimum requirements.

ELECTRICITY ON THE FARM

Very closely connected with this electrical development in the household is that which, with equal steps of advance, has gone on in farm life. We are still very far from the complete modernization of rural America, but the process has gone very far, in a typical way, in some sections, especially those that are embraced by the far flung circuits of a big urban central station system reaching out into the country, or are traversed by long distance transmission lines, especially those distributing the energy of some harnessed water power. The Iowa State College of Agriculture reports the following facts on a single township in that state:

There are 142 farm homes in the township and the average size of each farm is 151 acres.

Forty per cent. of all the farm homes have running water.

Thirty-three per cent. have bathtubs.

Thirty-four per cent. have indoor toilets.

Eleven per cent. have electric lights.

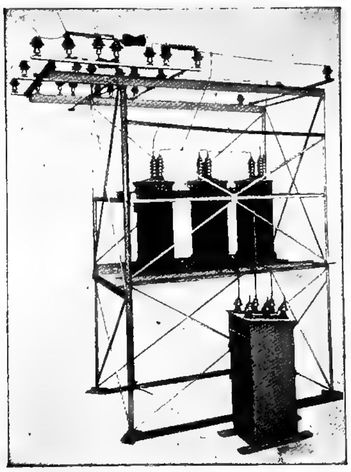
Thirty-five per cent. have gas lights.

Forty-eight per cent. have power washing machines.

Twenty-six per cent. have electric or gas irons.

Fifty-four per cent. have carpet sweepers or vacuum cleaners.

Fifty per cent. have furnace, hot water or steam heat.



An Outdoor Substation Used for Farm Supply

Ninety-three per cent. have telephones.

Forty per cent. have refrigerators.

Twenty per cent. have gas cook stoves.

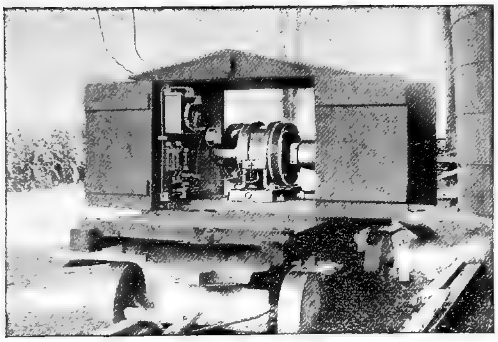
Thirty-three per cent. have oil cook stoves.

Thirty-three per cent. have sleeping porches.

Fifty-six per cent. have pianos.

One hundred and twenty-five of the homes have an average library of more than 100 volumes.

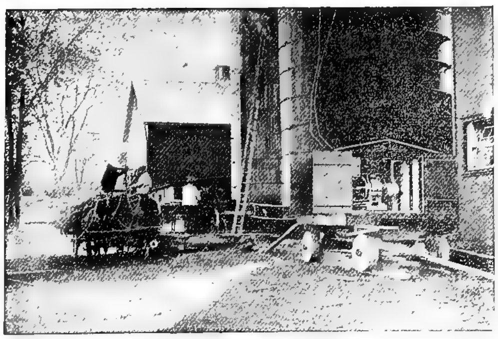
To which it might be added that probably few urban areas of similar size could boast an equal enjoyment of the resources of modern civilization. No longer need farm life be one of isolation and deprivation.



15 H.P. Motor on the Farm, Showing Mounting on a Truck with Housings, Arrangement of Starter, etc.

Speaking of the farmer's attitude towards electric service, Mr. D. O. Vaughn, manager of the Sidney, O., Electric Company, said in March, 1920, before the Ohio Electric Light Association: "We have found that the average farmer is a much better user of appliances than the average consumers in the small town." No figures exist on the subject of the exact extent to which farms in the United States are electrified, or are being "changed over," other than those given elsewhere in this chapter; but it is quite probable that not less than 250,000 farms every year are added, through putting in plants of their own or being "hooking onto" the circuits that run near them.

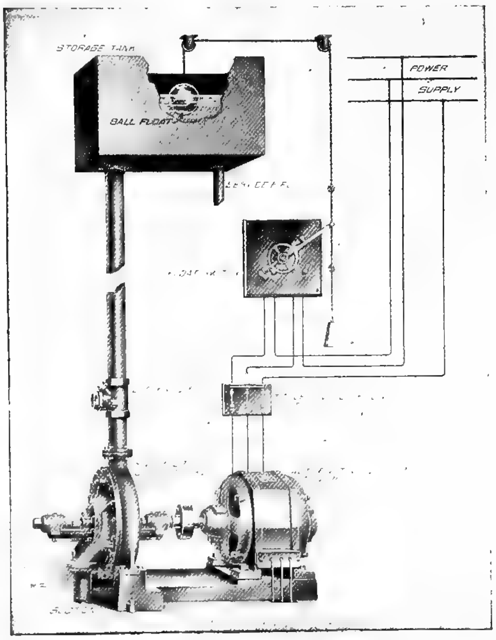
As in the case of domestic utilizations, the list of possibilities and of actualities is endless. Let us enumerate the leading ones dependent upon the use of the electric motor such as ensilage cutters, cordwood saws, shellers, huskers and shredders, grain threshers, hay balers, clover hullers, rice threshers, feed grinders, fanning mills, grain elevators, corn crackers, oat crushers, cider mills, alfalfa mills, horse clippers, groomers, etc., sheep shearers, hay cutters and hoists, grain graders, bone grinders, root-crop cutters, clover cutters. While there is not yet much electric plowing, it can and has been done successfully, and was one of the earliest examples of electric power applications in agriculture. Electric pumping is a pronounced success, and large schemes of irrigation have been successfully carried out with its aid; which is also true of such allied work as spraying fruit trees, watering onion crops, etc. Electrical refrigeration has already been referred to but there are also ice cutting and haulage. The adaptation of electric power to dairy work is already very familiar, and electric drive is applied to milkers, cream separators, churns, bottle washers, cream testers, milk mixers, curd grinders, butter tampers, etc. One dairy reports that by the use of its electrically driven system, seven cows could be milked and the milk transformed into its various products in seven minutes—the skimmed milk actually been fed to the calves before it had lost its natural heat. Many heating and cooking devices find a new employment around the farm in ways that would quickly suggest themselves, such as incubation, and in others that are by no means so obvious. One incubator put into service at Muskogee, Okla., as long ago as 1913, had an egg capacity of 30,000, the growth of the chicks being stimulated by electric light, and motor-driven blowers circulating the



Electric Motor Driving Ensilage Cutter

heated air. The use of electric light has also been resorted to as a means of increasing the hen's output of eggs. Other novel uses in agricultural regions include the operation of cotton gins, the driving of fruit conveyers, the operation of orange

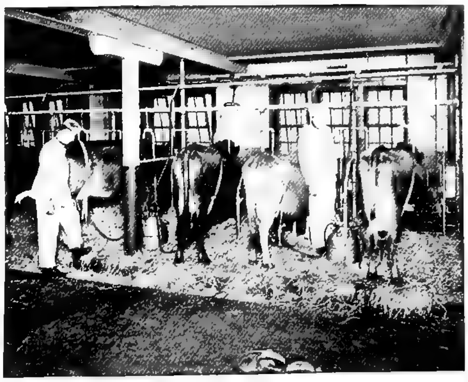
sorting machinery, the use of electric heat, as in California for the drying of walnuts and dessicated fruits; and the resort is credibly reported, and is at least plausible. —to the vacuum cleaner for relieving dogs of fleas, and other animals of equally obnoxious vermin. From Iowa has been reported the success of electrical threshing on a large scale. It is true that much of this farm work can be done, as hitherto by steam or gasoline engines, but as in the threshing where current at 5 cents per kilowatt hour unit is used, electricity is considerably cheaper or safer. Many of the uses have also depended upon animal power; but while the first cost of say a 1 hp. electric motor is to be put at not in excess of $75 a good horse fetches $150 to $250; while the average operating electrical cost is about 6 cents per horsepower hour but that of animal labor is about 8 cents. Human labor is almost out of the



Motor-Driven Centrifugal House Pump, Showing One of the Systems of Automatic Control Rendered Possible by Electric Drive

calculation in these days, and may be set down at perhaps $1 per hour, and poor at that. It is commonly assumed that it takes 10 men to exert one horsepower or thirteen men to exert one kilowatt. While it is also a conservative estimate that a horse "eating its head off," only works 11½ per cent. of the time, or less than three hours a day on the average throughout the year.

Here is a list of the most popular household electric appliances showing in eight-



Milking with Vacuum-Operated Milking Machines

hour days the amount of time each device will save the user in the course of a year:

	Eight-Hour Days
Electric clothes-washing machine	19½
Electric vacuum cleaner	19½
Electric dishwashing machine	13
Electric iron	6½
Electric ironing machine	13
Electric sewing machine	3¼
Electric toaster	3¼
Electric percolator	3¼
Electric fan	3¼
Total	84½

In this calculation, which was prepared by the Rochester (N. Y.) Gas & Electric Corporation, and published by the *Electrical World* the saving merits of the devices are set forth in terms of days, but it is pointed out that there is no way of estimating the additional saving of physical effort accomplished through the liberal use of electric service.

ELECTRICITY APPLIED TO PLANT LIFE

Electricity may be applied in various ways to the treatment of plant life, beginning with seeds. Forty years ago, Sir W. Siemens carried on some very interesting experiments for the purpose, and since that time many other trials of various kinds have been made in electrical stimulation of plants. The early experiments included

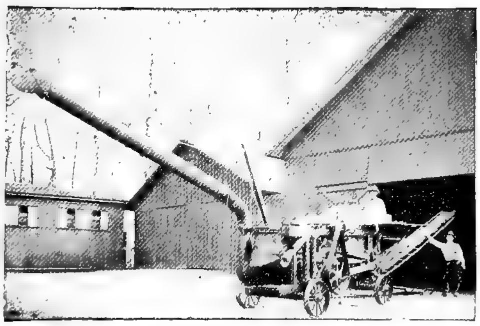
attempts to utilize the natural electricity of the air by means of rods or lightning conductors, and direct it upon the growing crops. Then came also the generation of

Motor-Driven Feed Grinder and Wood Saw

static electricity for the same purpose; and another kindred method was that of burying metallic plates in the earth, and connecting them with aerial metallic conductors. These tests were followed by the use of current from dynamo-electric machines. The current was applied in different ways, sometimes through the ground and sometimes by placing the wires in a kind of network over the growing crop, so as to immerse it, so to speak, in a flood of electrical activity, either static or direct. Such work, as will be noted later, has continued down to the present time. Frequent experiments have also been made with the use of electric light.

Among the latest experiments are those directed at the treatment of seed. The process is that of Mr. H. E. Fry, of Godmanstone, England, who as recently as 1919 was reported as applying electrified seed to an arable area of not less than 300 acres with notable success. The process is a very simple one, and consists merely in passing a weak current through the seed for a given length of time. In order to render the seed permeable by such a current, it is soaked or steeped in a conducting solution of some metallic salt. After that it is carefully dried, and a good deal depends on the skill with which the drying process is carried out, at a temperature neither too high nor too low; and of course, different seeds require different degrees of steeping and drying. Any ordinary source of electricity suffices for the application. The stay of the seed in the electrifying tank varies from one to seven hours or more, and considerable current can be applied, as for example in treating 100 sacks of seed wheat. The electrification appears to produce some very important results. There is an increase in the yield, as for instance 4 to 20 or more bushels of grain per acre; or a sack to 5 sacks or more, or from 10 to 50 per cent. In addition, the wheat straw is increased in both strength and length. This is a notable item, though indirect, as it enables the crops to stand up against damaging storms that lay flat the adjacent crops raised from unelectrified seed. The process has been applied to wheat, oats and barley, but equally good results have been obtained with many other seeds, such as turnip, mangel, cabbage, tomato, tobacco, cotton and others. Dr. Chas. Mercier, F. R. C. P., describing the process and its results in the London *Electrical Review* says:—"Evidently there is a great future before the electrification of seed."

An exemplification of such a plan and of the direct application of electricity to the growing crop may be found in the re-



Six-Roll Husker and Shredder Belt-Connected to an Electric Motor

cent method and apparatus of Mr. R. D. McCreary, of Chicago, whose patents have been taken up by the American Electro Agricultural Company, Chicago, to market the appliances developed. Instead of using overhead circuits involving poles and the stringing of wires, Mr. McCreary literally drives high frequency current

through the surface of the soil and into the ground by distributed electrodes imbedded about 6 inches, arranged parallel to each other and on opposite sides of the field under cultivation, along the fence lines. The control or application of the electrical energy is effected by coating the seed with a finely divided non-deteriorating metal before planting. Thus there is created a condition of lines of low resistance and analogous to that in the coherer of a wireless telegraph set, favorable to the reception and utilization of high frequency waves of current. After germination, it is said, the metallic element has been deposited in the heart of the roots of the growing plant, thereby affecting favorably the rapidity of growth, early maturity, and volume and quality of production. Tests made at Lombard, Ill., showed that corn came up 3 or 4 days sooner; germination was increased 31 to 39 per cent.; growth was speeded up 30 to 40 per cent.; the volume of stalks was increased 35 to 40 per cent.; corn production was estimated as raised 30 to 40 per cent.; and the money value of the crop per acre was raised $25 to $35. In like manner, sugar beets were increased 15 per cent. in weight volume, and 14 per cent. in sugar content; and the value of the crop was raised $50 per acre. The apparatus installed, available indefinitely, cost less than $200, and the cost was less than 50 cents per acre for electricity and metallurgically treating the seed. The final average height of the corn was over 10 feet. It is believed that the principal effect secured is the addition of nitrogen to the soil, or the actual nitrification of the soil. One very distinct advantage among others is that of reducing the time of growth considerably—even one-half—so that the crop is in the stage of full maturity before there is any possible chance for frost to nip it and spoil it, as happens only too often, especially in the higher latitudes of the U. S. A.

A fair test of the results to be obtained by the application of the current with wires seems to be afforded by tests made in Wales on the fields of the Star-Delta Potato Club, which is connected with the South Wales Electrical Power Distribution Company. These tests as reported up to 1919, extended over two years and resulted in a large increase of yield. The field was 2.07 acres, typical heavy loam, approximately 70 per cent. clay and 30 per cent. sand. In 1916 it had grown oats, and in 1917 was two-thirds plowed but not manured. In 1917, potatoes were planted in May and lifted in October, various kinds being planted. The general results summed up as follows: 48.5 cwts planted, 292.87 cwts. lifted, or a ratio of 6 to 1. A British hundredweight is 112 pounds. In 1918, 41 tons of "colliery manure" were used, with 1120 lbs. of 30 per cent. super-

Electric Truck Used in Harvesting

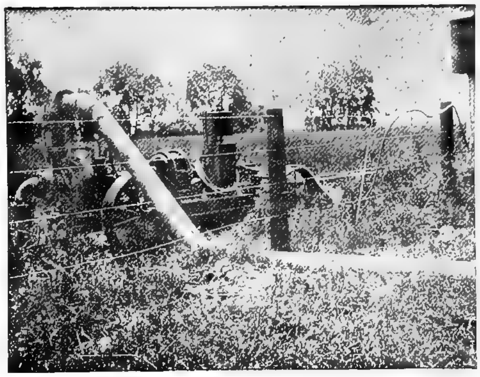
phosphate and 280 lbs. of sulphate of ammonia, afterwards, on the surface. The field was plowed lengthwise but not crosswise. Potatoes were planted in May and lifted in October, with these results: 48.6 cwts. planted; 370.4 cwts lifted; ratio 7.6 to 1. In 1917 the overhead network consisted of 5,850 yards of No. 24 galvanized steel wire spaced 6 feet apart, with crosswires making a mesh 6 feet square. These were supported from main copper conductors of No. 6 wire. The network was at first supported on insulators about 6 feet 6 inches from the ground; reduced later to 5 feet. In 1918 the arrangement was at right angles to that of 1917, and 1,860 yards of wire were used spaced 9 feet apart without crosswires, and moveable, and maintained as nearly as possible 2 feet about the "haulines." For the purposes of the experiment, 400-volt 25 cycle single phase current was used, raised to 32,000 volts in a 10 kva. transformer, and rectified in a Delon type of rectifier, which held the voltage to 39,-

000 volts in dry weather; and 30,000 in wet, in 1917; while in 1918 the potential used was 36,000 volts. This did not vary 5 per cent. either way. The current in 1917 varied from 2.5 milliamperes in dry weather to 4 to 7 in wet. In 1918 it varied from 0.35 in very dry weather to 0.8 during heavy rain, with an average of 0.5 during the normal damp weather prevalent in the district.

Coming now to the effect of artificial light on the growth and ripening of flowers and plants, the latest experiments of note in this field are those reported from Schenectady, N. Y., and published in the *General Electric Review* of March, 1918, by Dr. C. P. Steinmetz and J. L. R. Hayden. Gas-filled Mazda lamps were used as the source of light, as previous experiments in Dr. Steinmetz's laboratory had shown their light to be very efficient in its action on plant growth. The investigation was made on beans as the natural life of the bean plant is very short relatively, and it is therefore possible to get data in a fairly short time. The planting was done on December, 13, 1916, and discontinued 73 days later on February 24, 1917. Henderson's dwarf waxbush beans were used and planted in three rows, 18 inches apart, in a piece of ground 5 feet by 9 feet with good black soil in the Steinmetz orchid house. The Mazda lamps were burned continuously 24 hours a day in addition to the daylight, while the beans in the check test had only the daylight. Five 500 watt lamps were hung in a row 36 inches above the ground and 17 inches apart, with flood-lighting reflectors, directing the light on the bed; with a current consumption of 2.5 kw. After 44 days, 3 of the lamps were cut out, and 2 were left burning for the last 29 days, using 1 kw. Of the 73 days, 20 were cloudy, evenly distributed. The temperature of the greenhouse averaged 18 to 20° C. but above the experimental bed, in the rays of the lamps, it was about 2° C. higher.

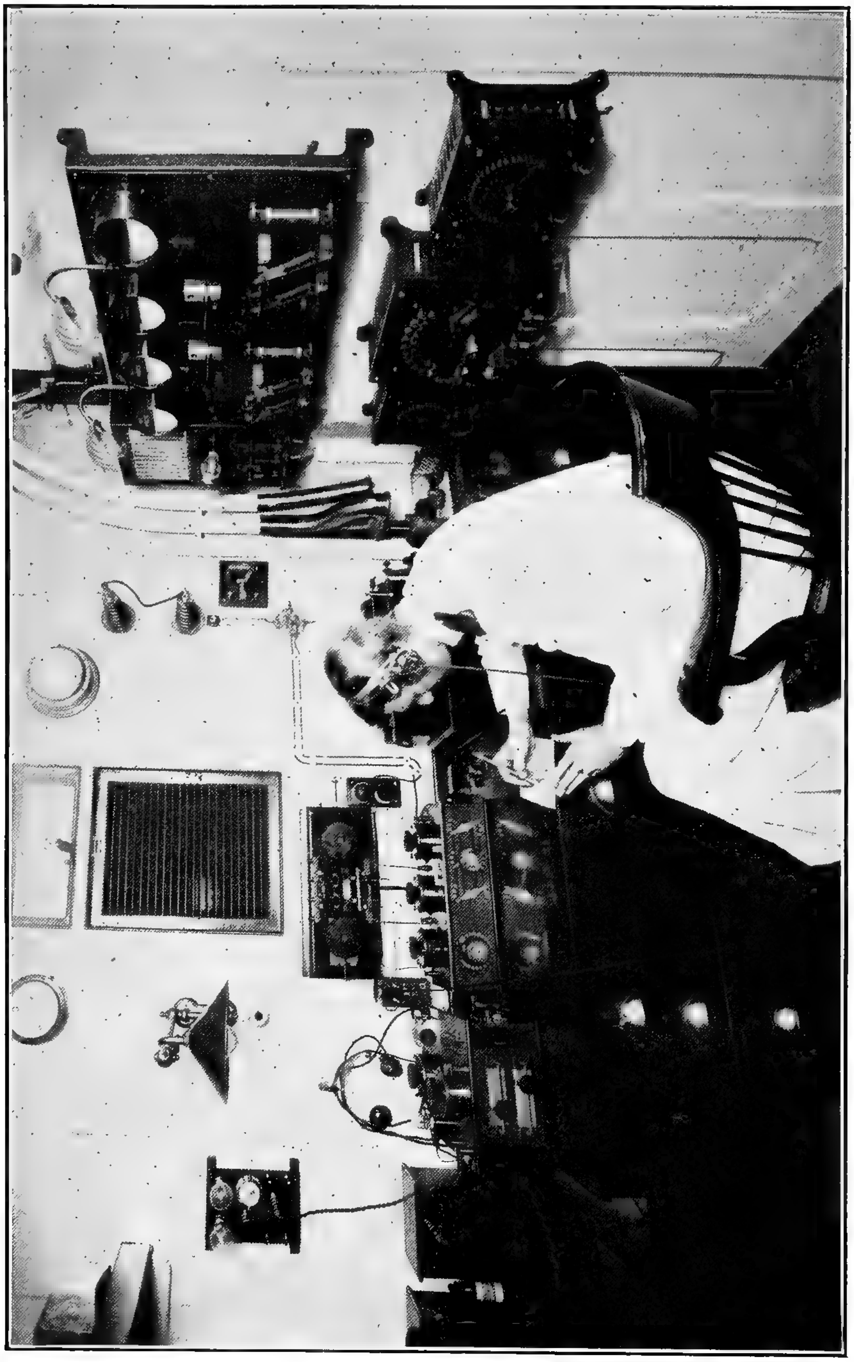
Summing up the results briefly, the gain from such intense artificial illumination was fairly uniform in the development of the foliage and in the appearance and development of the flowers and fruit, and averaged 46 per cent., which means that the process had "reduced the time required for the development by 46 per cent." In other words, "The plants have grown and brought fruit in a little more than half the time required under daylight above; the artificial light causes about double the rapidity of growth and development, or it saves about as much time as the time during which the intense illumination is maintained."

Offsetting this, however, is the fact that at 5 cents per kw. hr. the current if on all the time as in the test would cost $167; or if on only 18 hours a day at 2 cents, would



Portable Pumping Equipment Used for Irrigation

still cost $42. Ordinarily it certainly would not pay at such a cost to grow such a cheap product as string beans in that way. But "such speeding up of the growth and flowering of plants by intense artificial illumination may, however, be entirely economical and advantageous when the product has a high market value at some definite time, but largely loses its value after that time—for instance, Easter lilies, poinsettias, etc. These flowers are required at Christmas or Easter, and are in but little demand afterwards. If then by a period of cloudy weather, their flowering threatens to be retarded beyond the time when the flowers are in demand, their value may be saved by speeding up their development by intense artificial illumination for some days; and a considerable expense for current would then be economical." Under some conditions, even with plants of relatively low value, such stimulation would be economical and profitable.



Typical Ship's Equipment for Its Radio Cabin

CHAPTER VII

SOME LEADING EPISODES IN WIRELESS TELEGRAPH DEVELOPMENT

IN two separate chapters of Volume I of the "Story of Electricity," the history has been given of the telegraph and the telephone, with considerable detail and data also regarding the submarine cable, fire alarm telegraphs, police patrol systems and other branches of the great electrical art of communicating intelligence. It still remains to deal with the creation, growth and development of wireless telegraphy, the object of the present chapter. The record here submitted, based principally upon the continuous evolution of the work of William Marconi, will be found to be very notably reinforced and expanded by the information embraced in another chapter dealing specifically with American electrical achievement in the Great War. All such material is to be read, moreover, in the light of the personal data furnished in several of the biographical sketches contained in both volumes of the "Story of Electricity."

The effort to telegraph without wires goes back many years. Such renowned scientists as Faraday, Morse, Lord Kelvin, Joseph Henry, and Sir William Preece, had endeavored to solve this problem by means of various arrangements of apparatus adapted to utilize electric phenomena. These may be divided into three classes or methods.

First in order of time was the conduction system, the essential feature of which is that some other form of material conductor is substituted for wires. These substitutes were in all cases either the earth or bodies of water, since they are the only natural conductors that are sufficiently common and extensive for use. This method was preferably employed by means of wires which were stretched along both banks of a river and grounded at both ends, the length of wire on both sides of the river being greater than the distance by which the wires were separated from each other. If, then, a current was set up in one wire, a certain amount of this current would leak across the intervening space and produce current in the wire on the other side of the river. By means of a circuit maker and breaker, signals were thus transmitted from one bank to the other.

It appears that Professor Morse discovered this method of communication as early as 1842, while giving a public demonstration in New York of the practicability of his wire telegraph. A passing vessel parted the wires, which he had stretched from Governor's Island to Castle Garden, and in his discomfiture he immediately devised a plan for avoiding such accidents in the future, by so arranging wires along the banks of the river as to cause the water itself to act as a conductor for the electric current.

Sir William H. Preece, engineer of the British Postal Telegraph Service, subsequently worked out more extensive methods of operation upon this principle, but the distance covered did not exceed two

or three miles, and the large amount of wire required was a curious feature of this system of so-called "wireless telegraphy."

The second method originally employed by the scientists and inventors, known as the "inductive system," furnished a wider field of experiment. Of this there are two types: electromagnetic induction, and electrostatic induction. The electromagnetic induction method operated by the production of a magnetic field in one complete circuit, which induced a current in another complete circuit, by virtue of magnetic lines stretched or extending from the transmitting circuit to the receiving circuit. This method was also used by Sir William Preece in England, who was able to telegraph a short distance. This method of wireless telegraphy was also applied to railroad telegraphy. Impulses produced in a wire extending along the track were communicated to a moving train carrying a circuit which was connected through the wheels to the rails at opposite ends of the car.

The third method, known as electrostatic induction, differs from the electromagnetic method in that it does not make use of a magnetic field but depends upon high voltage or pressure for the purpose of "charging the earth," so to speak. Professor Dolbear, of Tuft's College, in 1886, and Thomas A. Edison, in 1891, devised systems for signaling by the electrostatic method. These systems of wireless telegraphy by conduction and induction are now of historical rather than practical value. Their utility was very limited and the cost of installation was greatly in excess of that of wire telegraphy.

HERTZIAN WAVES

In 1863 the eminent physicist, J. Clerk Maxwell, speculated theoretically that the medium known as "ether" should be able to transmit through it disturbances, with a velocity equal to that of light. Joseph Henry made the fundamental discoveries in this direction.

In 1887 these theoretical speculations of Maxwell were confirmed by the experiments of Prof. Henrich Hertz, a brilliant young physicist of Germany, who showed that electric oscillations, which for many years had been known to exist in metal rods, were propagated out into space from these rods in the form of wave motion, when a very sudden electrical discharge took place between the rods. These Hertzian waves are propagated in the universally diffused but impalpable medium called by scientists "ether."

A device by which Maxwell's predictions were confirmed is known as the "Hertz Oscillator." It was then found that it was possible to detect the existence of these waves by employing a loop of wire, with the ends brought close together. If this little loop of wire had a certain relation to the direction along which the waves ought to be traveling, minute sparks could be detected between the ends of the loops. This little loop of wire is called a "Hertz resonator."

These experimental researches aroused great interest in the scientific world. In 1889 Sir Oliver Lodge continued the experiments on a somewhat larger scale, and even connected the oscillator to a wire fence. In 1890 a French scientist, Edouard Branly, published an article describing a great variety of substances by means of which he could detect these waves.

In the year 1892, Sir William Crookes published his famous article in the *Fortnightly Review* entitled "Some Possibilities of Electricity," predicting that eventually means would be discovered for transmitting wireless signals.

In the following year, 1893, Nikola Tesla delivered lectures before the Franklin Institute in Philadelphia and the National Electric Light Association at St. Louis, on the subject of "High Frequency and High Potential Currents." Tesla, after discussing and describing certain apparatus for high frequency illumination and power transmission, referred to the possibility of the transmission of intelligible signals, or perhaps even power, at any distance, without the use of wires. Tesla said that he knew that the great majority of scientific men would not believe that such results could be practically and immediately realized, but he was firmly convinced that it could be done and he hoped they would all live to see it done. He then started to do it.

In 1894 Sir Oliver Lodge published a series of articles in the *London Electrician* on the work of Hertz, and described various forms of detectors or receivers which would render manifest the existence of Hertzian waves. Some of these detectors were discoveries of his own and others were repetitions of Branly's discoveries.

In 1895, a Russian scientist, Professor A. S. Popoff, in a lecture delivered and printed in the *Journal of the Russian Physical Chemical Society* repeated some of the experiments of Branly and Lodge, and also gave an account of some experiments of his own relative to certain substances which he had noted were detectors of the waves. In this article Popoff also described an experiment which he had made at a laboratory, in which he noted that if one of his detectors, consisting of a Branly tube containing filings, was connected to a lightning conductor at one end and to the ground at the other, with an electric bell and battery in circuit, the existence of a distant thunder storm in the Ural mountains could be noted. He concluded his paper by expressing the hope that, with further improvements and the discovery of a source of vibrations possessing sufficient energy, his apparatus might be adapted to the transmission of signals at a distance.

MARCONI'S DISCOVERY

In 1896, the lay and scientific world was astounded at the announcement that the hope of Popoff and the dream of Crookes had been fulfilled in the successful transmission, to a distance, of intelligible Morse signals through space by means of Hertz waves, without the use of connecting wires, and that Guglielmo Marconi had successfully discovered and invented practical means for accomplishing this result.

The system invented by Marconi consisted, essentially, of signalling apparatus at a sending or transmitting station, for controlling in a definite way the spark gap, and causing it to produce Hertzian waves of definite form, character and duration, and sparking apparatus subject to nice control and means for radiating and propagating the waves so produced through the ether to another distant station, known as the receiving station, where they were received and caused to manifest themselves through the medium of suitable apparatus,

Guglielmo Marconi in Uniform of the Italian Navy

as telegraphic signals and messages. Details of his apparatus are given elsewhere in this chapter.

The Government of Great Britain owns and operates all British land telegraph

systems, and, early in 1896, Mr. Marconi demonstrated to the satisfaction of Sir William H. Preece, the Chief Telegraph Engineer of the British Post Office, that his invention had then achieved what no other scientist or physicist before him had been able to achieve, namely, the transmission of intelligible signals by means of Hertz waves, and to receive them as such, at a distance, without wires. In further demonstrations before officers of the British Navy, the British Army, and the British Post Office, on Salisbury Plain, England, in September, 1896, transmission over a distance of 1¾ miles was achieved, and the wireless era began definitely.

Further demonstrations were carried out in 1897 before representatives of the British Post Office and the British Navy, when the distance was increased to four miles, and, in the same year, communication was successfully established over a distance of nine miles across the Bristol Channel.

The success achieved by Mr. Marconi in this early work, done at the invitation of the British Government, attracted the attention of other governments. Professor Slaby, of Berlin, witnessed these remarkable demonstrations and was shown the apparatus by means of which these marvelous results were achieved. At the conclusion of the demonstrations Professor Slaby went back to Germany and in an address described what he had seen as a great discovery.

Later, in 1897, Mr. Marconi demonstrated the new telegraph to the Italian Government, and at Spezia, Italy, he installed his apparatus on one land station and on some Italian warships. During these demonstrations, successful communication was established up to a distance of twelve miles.

Early in 1898 stations were erected at "The Needles," Isle of Wight, and at Bournemouth on the mainland, and communication was established for a distance of over fourteen miles between these two places.

In 1898 the first commercial application of wireless telegraphy, for the purposes of journalism, was made. A Dublin (Ireland) daily newspaper—*The Daily Express*—fitted out an ocean-going tug with Marconi apparatus, and by means of that installation, and a similar installation at Kingston, Ireland, the Kingston yacht races, held in the Irish Channel that year, were reported by wireless telegraphy. A distance of twenty-five miles was attained.

In 1899 communication was established, for the first time, by wireless telegraphy, between England and France, across the English Channel, the distance between these two stations being thirty-two miles.

In the fall of 1899 the first practical application of wireless telegraphy in the United States was made by Marconi himself, under an agreement with the *New York Herald* to report the International Yacht Races, held off Sandy Hook.

At the conclusion of these races, at the request of the United States Government, Marconi equipped the armored cruiser *New York,* the battleship *Massachusetts,* and the torpedo-boat *Porter* with wireless telegraph apparatus, and several officers were detailed to investigate his apparatus during tests conducted on these warships. The official report of these tests stated that communication was effected over a distance of forty-five miles. In 1900, in consequence of the successful tests during the naval maneuvers, the British Navy entered into a contract to equip thirty-two of its ships and stations with Marconi apparatus.

Marconi was improving his apparatus from time to time, in order to attain still greater results, and in 1901 the apparatus was installed in the United States on the Nantucket Lightship. In December of 1901 he transmitted an intelligible signal across the Atlantic, between Poldhu, Cornwall, England, and a station in Newfoundland. The announcement of this aroused the utmost astonishment and excitement. The Anglo-American Cable Company were so disturbed that they started a suit against Marconi, asking for an injunction to prevent him from erecting a permanent station in Newfoundland, on the ground that they had the exclusive right for a term of years for all cable stations in Newfoundland.

In the next month Mr. Marconi was given a complimentary dinner by the American Institute of Electrical Engineers in New York, commemorative of his won-

derful achievement. Such distinguished scientists as Elihu Thomson, Alexander Graham Bell, and M. I. Pupin were present. Among those who sent congratulatory telegrams were Thomas A. Edison and Nikola Tesla.

Next, in February, 1902, Marconi performed some extraordinary receiving experiments aboard the American Line steamship *Philadelphia,* en route from England to New York. At that time he received messages over a distance of 2,099 miles from Poldhu. In July of the same year signals were received from Poldhu on the Italian battleship *Carlo Alberto* when lying at Kronstadt, 1,600 miles from Poldhu.

Shortly afterward the long distance station at Cape Cod, Mass., was equipped for transatlantic work, and a station was erected at the expense of the Canadian Government, at Cape Breton, Canada. A transatlantic message was despatched from Cape Cod to Poldhu on January 19, 1903, and in the same year the first International Conference on wireless telegraphy was held in Berlin for the formation of rules to govern the ship operation and shore radio stations in the principal countries.

Great activity was seen now in the commercial development of wireless telegraphy in the United States. In 1907 the Marconi transatlantic stations at Clifden, Ireland, and Glace Bay, Nova Scotia, were opened and traffic was accepted for all points in England and Canada. Great impetus was given to the use of wireless aboard ship, in the year 1909, by the collision of the steamship *Republic* with the steamship *Florida* off the coast of the United States. Assistance was called for through the wireless equipment on the *Republic,* which was answered by vessels within range, and as a result the passengers and crew were saved before the vessel sank. This was by no means the first rescue made through the medium of wireless telegraphy, but it apparently made a greater impression on ship owners than any previous similar event.

Then came Marconi's record-breaking transmission of messages between Clifden, Ireland, and Buenos Aires, Argentine Republic, a distance of over 6,000 miles.

During 1910, 1911, and 1912, a world-wide development in the commercial application of wireless telegraphy took place. All vessels of any considerable tonnage throughout the civilized world were equipped with modern radio apparatus, and in addition shore stations were erected at the principal seaports. Compulsory legislation was then enacted by the great nations, compelling the use of wireless apparatus on ships above a certain tonnage. Not only was the installation of apparatus required, but, according to the regulations of the International Radio-Telegraphic Convention, to which the United States subscribed in the year 1912, the wave lengths employed in radio-telegraphy for ship use were restricted. It was required that the transmitting apparatus be adjusted to radiate a wave of different length, and standards were also adopted for the character of the radiated wave.

The next step of importance in the commercial application of wireless telegraphy was the completion of the Marconi Company's high power stations at Carnarvon, Wales, and New Brunswick, New Jersey, in 1914. Stations were also erected to operate between Bolinas, Cal., and Kahuku, on the Island of Oahu, Hawaiian Islands. The California-Honolulu circuit was opened to public service in September, 1914.

About this time the German Telefunken Company erected a high power station at Sayville, Long Island, to communicate with a similar station at Nauen, Germany, and a high power station was erected by another company at Tuckerton, New Jersey, for communication with Hanover, Germany.

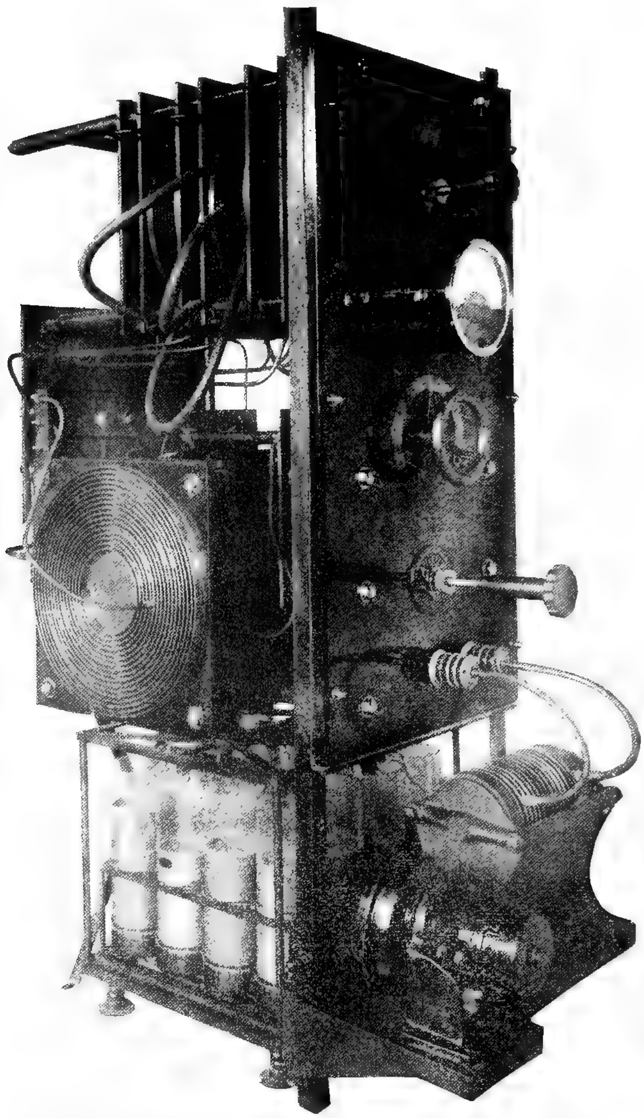
Practical tests of radiotelegraphy aboard trains were made in 1913 by Marconi, and in 1915 direct wireless telephonic conversation was effected between the United States Government station at Arlington, Virginia, and Honolulu, in the Hawaiian Islands. A little later wireless telephonic conversation was held between Arlington, Virginia, and Paris, France.

During the period of 1912 to 1917, the United States Navy Department connected all its important naval bases by radio.

SCIENTIFIC PROGRESS

It is not practicable here to give a complete résumé of the scientific progress in radio during the past seventeen years, but some of the more important developments will be briefly noted, while the narrative in the chapter on the Great War virtually brings the record down to date.

Marconi's original transmitter consisted of an induction coil, the secondary of which was connected to a spark discharge gap. One terminal of the gap was connected to a vertical insulated wire and the opposite terminal to earth. Marconi's early receiver consisted of a glass tube fitted with metal lugs on either end, between which was placed a small quantity of metallic filings. This device, known as a "coherer," was connected in series with a telegraph relay and a battery. One terminal of the coherer was connected to



Powerful Type of Transmitting Apparatus for Use Aboard Battle Ships, developed by the American Marconi Company. This transmitter is designed for rapid change in wave lengths and also permits a wide variation of power

the aërial wire and the other to earth. It is believed no coherers are now in use.

Under the influence of the electrical oscillations induced into the coherer circuits by the distant transmitter, the conductivity of the filings instantly increased, reducing the resistance of a battery circuit through the telegraph relay. A vibrating hammer device, known as a decoherer, tapped the coherer at the termination of each signal and placed it in condition to become responsive to the next impressed group of oscillations.

Marconi next improved the transmitter provided for removing the spark gap from the antenna circuit, placing it in a local or closed circuit, which, on account of the increase of capacity over that of the aërial wires, generated more powerful oscillations. Then by means of an oscillation transformer, these locally-generated radio-frequency currents were transferred to the antenna or radiating wires by utilizing the principles of resonance.

This change in design resulted in more powerful radiation from the transmitter aërial with less damping of the oscillations, which reduced the interference between stations. Increased freedom from interference was also obtained at the receiver by coupling the coherer circuit to the aërial wires through a specially designed receiving transformer.

It is fully established that Marconi was the first to realize the necessity for complete resonance between the transmitter and receiver circuits. His original "four circuit tuning" patent covering this principle has become famous throughout the world, and its claims have been sustained in the major courts wherever contested. This patent was filed in England, April 26, 1900.

Sir Oliver Lodge made a number of investigations during Marconi's early work, and was instrumental in developing a special system in collaboration with Dr. Muirhead. Lodge filed one basic patent, owned by the Marconi Co., on loaded aërials of large capacity, which proved valuable.

Another important invention of Marconi's was the perfection of the magnetic detector which depended for its operation upon the ability of high-frequency currents to demagnetize a moving band of iron under the influence of permanent magnets. This detector made more practical the use of a telephone receiver in place of the telegraph relay for receiving signals, and it allowed greatly increased speed of reception.

The use of the telephone receiver marked a distinct gain in the commercial progress of radiotelegraphy, because it permitted the operator to distinguish between radio signals sent out by a distant transmitter, and the interfering sounds of atmospheric electricity which differed in tone.

The induction coil as a source of high voltage current for the transmitter was early replaced by Marconi and other investigators with the high voltage alternating current transformer and generator. Alternating current for the commercial operation of radio sets was introduced in the United States during the years 1901 and 1902.

Investigators were now numerously entering the field and endeavoring to discover more sensitive means than the coherer for detecting radio currents. The electrolytic detector attributed to Fessenden in the United States and Schloemilch in Germany was tried, but gave way to the crystal detector and valve detectors.

The advantages of the high-frequency spark discharger were early recognized both in the United States and abroad, and during the years 1903 to 1905, transmitters operated by 125 and 133 cycle current were widely introduced in the United States.

The principal advantages of the high frequency spark are that it enables the receiving operator to distinguish radio signals from the interfering discharges of static or atmospheric electricity, and makes possible the use of higher powers with antennae of given size.

About this time came also the development, commercially, of the synchronous rotary spark discharger for the transmitter.

The next great advance in respect to the receiving detectors of wireless telegraphy was the discovery by Professor J. Ambrose Fleming, in England in 1904, that if a metallic plate was sealed within the bulb

of an incandescent lamp filament and the plate and filament were connected to the secondary of a receiving transformer, the device became a very sensitive detector of high-frequency oscillations. The discovery of this fact proved to be the foundation work for a very valuable series of improvements continuing down to date. The claims of Fleming's patent have been warmly contested in the courts; but in every case his claims were fully sustained. The phenomena were first noted by Edison in 1883.

A new form of oscillation detector owned by the Marconi Co. appeared in the year 1906. It was invented by General Dunwoody, U. S. A., who discovered that a crystal of carborundum acted very efficiently as a receiver for electric wave telegraphy, and it was found later by Professor G. W. Pierce, of Harvard University, that these crystals possessed the property of rectification, i.e., they would convert a high-frequency alternating current into a unidirectional pulsating current suitable for reception in the telephone receiver. Further investigations by Dr. Pierce and others into the property of minerals and compounded crystals revealed that galena, silicon, molybdenite, iron pyrites and others possessed the property of rectification and were equally suitable as oscillation detectors for wireless.

One useful form of oscillation detector introduced at this period was the so-called Perikon detector, a trade name given to a detector consisting at first of a crystal of zincite in contact with a crystal of chalcopyrite and later a crystal of zincite in contact with one of bornite. This was due to Mr. G. W. Pickard.

Dr. Lee DeForest in 1907 placed a grid element between the filament and the plate of Fleming's original oscillation valve, and named his useful device the "audion."

The early transmitters were necessarily of small power. With the introduction of alternating current generators, powers of 1 and 2 kw. were soon attained for ship stations. Attempts at higher powered land stations made by some workers did not prove successful, but the Marconi Co. in England and at South Wellfleet in the United States, in 1902, successfully developed transmitters of 15 to 40 kilowatts.

The Marconi Wireless Telegraph Company, Ltd., of England, attacked with great vigor the problem of designing high power transmitters for long distance wireless communication. The first fruits of this series of experiments was the establishment of twenty-four-hour transatlantic wireless service between Glace Bay, N. S., and Clifden, Ireland, in 1907.

For the first time in the history of the art Marconi employed at these stations high voltage direct current for charging a battery of condensers. This current was obtained from 6,000 storage cells connected in series, which in turn were charged by three 5,000-volt direct current generators connected in series. By the use of a high-speed rotary disc discharger perfect musical tones were secured suitable for telephonic reception.

Another innovation introduced during this period at the Glace Bay and Clifden stations, was the employment of air at atmospheric pressures as the di-electric medium for the high voltage condenser.

Early in the development of the radio art, it was suggested that the use of undamped oscillation transmitters would materially increase the distances of transmission and permit a greater degree of selectivity at the receiver.

Vlademar Poulsen, in 1903, suggested improvements on Duddell's singing arc, later perfecting it to the point where it could be employed to generate the extremely high frequency currents necessary for the generation of electromagnetic waves, but his early apparatus did not operate with the stability of Marconi's spark discharger, and consequently it was not used commercially until its development by American engineers since 1908. High-powered arc transmitters of 30 to 100 kilowatts have been employed for trans-Atlantic and trans-Pacific communication. In fact, the United States Navy has in use at present arc generators of 350 kilowatts capacity.

E. F. W. Alexanderson, of the General Electric Company, U. S. A., during 1914-16, produced a 75-kilowatt machine which generated current at 50,000 cycles per second. This machine ran at reduced speed as compared with earlier attempts and thereby eliminated one of the most

difficult problems encountered in the design of radio-frequency alternators.

Dr. Rudolf Goldschmidt, of Hanover, Germany, designed in 1910 a high-frequency alternator which was a departure from machines of the Alexanderson type, the principal point of difference being that Goldschmidt's alternator generated current at frequencies up to 60,000 cycles per second from an armature which revolved at a speed of 3,000 R.P.M. With this machine successful communication was established between Tuckerton, N. J., U. S. A., and Eilvese, near Hanover, Germany, in 1913.

About the same time, Joly, and Count Arco of Berlin (1912) evolved a system for increasing externally to the generator the frequency of a comparatively low radio frequency alternator, and so successful were their first experiments that communication was established between Nauen, Germany, and Sayville, L. I., U. S. A.

Around 1908–1909, what is known as the multiple plate discharger appeared in the radio field and it soon had application to transmitters up to 10 kilowatts and later to 50 kilowatts.

E. H. Armstrong discovered that the vacuum valve detector possessed the property of repeating radio frequency oscillations into its local battery or telephone circuit, and hence by coupling this circuit back to the grid circuit, the incoming oscillations were magnified several hundred times. A most noteworthy increase in sensitiveness was obtained. Several other investigators, among whom may be mentioned Roy A. Weagant, chief engineer of the Marconi Wireless Telegraph Company of America, found that a three-element vacuum valve with proper accessories became a generator of high frequency oscillations and could be employed to produce the heterodyne effect first disclosed by Fessenden. These experimenters employed the vacuum valve as a combined oscillator, amplifier, and "beat" receiver, all these actions taking place simultaneously within the same bulb. Immense development in popular "radio" is now proceeding along this line.

H. J. Round, in England, who performed important experiments in this direction in 1913 and 1914, produced a vacuum valve oscillator of sufficient power output at radio frequencies to carry on radio telephonic and radio telegraphic communication over considerable distances.

Various methods of applying vacuum valve bulbs to radiotelegraphy were perfected during the year 1916. These bulbs have been used in a battery as a source of radio frequency current, as a means of amplifying the output of a radio-frequency alternator, and as a means of controlling the antenna current from such an alternator. At the receiving station the vacuum valve is employed singly for regenerative amplification or in the cascade for radio-frequency or audio frequency amplification. Valves also have been extensively employed as repeaters on long distance wire telephone lines.

In the summer of 1916 Marconi installed at Carnarvon, Wales, his timed spark transmitter which generates continuous oscillations by overlapping wave trains in the antenna circuit. Very successful results were obtained, perfect communication having been established with the American Marconi Company's High Power Stations at Chatham, Massachusetts, and New Brunswick, New Jersey.

On November 5, 1921, President Harding opened formally the great new radio "central station" at Rocky Point, Long Island, some seventy miles from New York, by sending a radiogram "peace message" addressed to no fewer than 28 foreign nations from the White House in Washington. The switch was closed at 3 p.m. and by 3.05 the message had been taken up wherever a radio station existed in Argentina, Australia, Belgium, Brazil, Bolivia, Chile, Canada, Cuba, Denmark, England, Ecuador, France, Greece, Germany, Hawaii, Holland, Italy, Japan, Mexico, Norway, Nicaragua, Poland, Peru, Paraguay, Spain, Switzerland, Uruguay, Venezuela. In less than ten minutes word came through the receiving station nearby, at Riverhead, L. I., of the reception of the message by several of the countries named above. This great transmitting station occupies a site of ten square miles, and the first power house section accommodates, with auxiliary apparatus, —transformers, magnetic amplifiers,

switchboards, etc.,—two 200 kw. high frequency Alexanderson transmitting alternators, furnishing energy at frequencies covering a wavelength band of 15,800 to 20,000 meters; but the interesting fact is that there are no radio operators at Radio Central, the actual transmission taking place by remote control from the central traffic office in Broad Street, New York City. The final installation around the power house at Rocky Point, with its community house, etc., will comprise twelve antenna units fed by ten high frequency alternators with a power output of about 2,000 kilowatts. Each antenna unit of six great towers is part of the system over which a sending speed of 100 words a minute per transmitting unit is at present possible. At the time of the opening of the plant, two units of six towers were in operation. Into these first twelve towers, resting on concrete bases, each leg sunk nine feet below the ground, went 1,800 tons of structural steel. The ground system for both antennæ consists of 450 miles of copper wire buried in starfish and gridiron fashion. Each of the antennæ consists of sixteen silicon bronze cables ⅜-inch in diameter stretched horizontally at an overall height of 410 feet from a bridge cross arm 150 feet in length of span; and the distance between any two adjacent towers is 1,250 feet. In all 50 miles of the cable have been used in the first two antenna systems. The antenna units will all extend like spokes of a wheel around the "hub" of the central station.

CHAPTER VIII

THE EARLY STORY OF THE AUTOMATIC TELEPHONE SYSTEM

THE editors are indebted to the Automatic Electric Company for the subjoined interesting details as to the early development of automatic telephony:—

The pioneer history of the Automatic System of telephony is a record of remarkable struggle against natural conservatism and established ideas. It not only had to prove its ability to meet actual operating conditions, but it had to be demonstrated that the service it rendered could win and hold the favor of the public. The fact that the Strowger Automatic Telephone System made any progress at all during the first ten years is proof that it possessed unusual merit.

In its simplest form a telephone system is, of course, a single line permanently joining two telephones. In its most useful form it is a line joining a telephone to some means of connecting it at will to all other telephones in the country. Very soon after the discovery of the telephone principle came the idea of the telephone exchange, that is, arranging the terminals of a number of telephone lines at a common point in a systematic manner and providing means for connecting any pair of terminals or subscriber's lines.

Each telephone line terminated in a socket or jack at the switchboard, and was also connected to a visual or audible signal for attracting the operator in charge when a connection was desired. The connections were made by the use of a number of plug-ended flexible conductors, called cord circuits. Before long, however, the number of calls became too great to be handled by a single board, and this necessitated setting up other boards and transferring calls from one board to another.

The next development was the present multiple switchboard by means of which each operator, although handling calls incoming from only a small number of subscribers, has access to every line in the office for the purpose of completing calls, the terminals of each line being connected to a jack in every operator's position.

The multiple switchboard, although having the effect of speeding up the connections considerably, still left much to be desired in the way of good telephone service. Manual operation of switchboards had not been practiced many years before machine-made connections became recognized as desirable. The inefficient service and petty annoyances so largely characteristic of manual systems of today were by no means unknown at that early date.

It was not until 1888 that serious thought was given to rectifying such conditions. One of the first names found associated with the automatic idea is that of Almon B. Strowger, an undertaker of Kansas City. Like a great many other people he was often annoyed by the lack of satisfactory results from the manual operation of telephone systems; so he set himself seriously to the task of devising some

method by which subscribers could set up and release the telephone connections for themselves, and thus dispense with the service of operators.

Mr. Strowger applied himself to his task with all the enthusiasm of an amateur, but with a tenacity of purpose that few amateurs possess. His crude method of procedure was to build something that would work, regardless of the number of parts or the complexity of design. When this was accomplished he applied himself to the problem of simplification. Several months of work at nights and at odd hours during the day finally resulted in a mass of drawings and a rather crude model of a telephone and switch for which, in March, 1889, a patent was applied.

While the details of Mr. Strowger's first switch are unimportant compared with later models, it is interesting in that it foreshadowed in many respects the fundamental principles of the switch of today. Although the switches of the first few years differed radically from the original model, the essential features of the modern switches illustrate a curious reversion to type that has been characteristic of many other developments of the telephone and other arts. The chief features of the original switch may be summarized as follows:—the terminals of the telephone lines were arranged in rows about the interior of a hollow cylinder; the desired line was reached by vertical and rotary motions of a shaft carrying a wiper spring; each telephone line besides being connected to its particular contact in each switch was connected to the wiper of an individual switch; a release magnet completely restored the shaft to the initial position.

The technical difficulties involved in building the original type of switch and of making the parts sufficiently accurate, were so great that it soon was decided to change the form of the switch to that of a flat disc. Instead of mounting the line contacts in rows one above the other, they were arranged in a circle around the circumference of a disc. The wiper was mounted on a shaft which was run through the disc at right angles to its plane.

This switch, having but one motion, was much simpler than the first, but its capacity was only 100 lines. The rotary motion of the wiper shaft was supplied by two sets of magnets actuating pawls; one set moved the wiper over ten contacts at a time, while the other moved it over one contact at a time. A release magnet disengaged both pawls permitting the pawl to return to its original position under the action of a weight and pulley.

The first automatic telephone exchange placed in public service was installed at LaPorte, Ind., in 1892. The switchboard had a capacity of 100 lines and each switch embodied the essential features described above. The calling device at the telephone consisted of three push buttons, the first for selecting the group of ten desired, the second for selecting the particular line in that group, and the third for operating the release magnet. For example, if telephone number 57 was desired, the tens button was pushed five times, thus sending five impulses of current through the magnet which rotated the wiper shaft over five groups of ten contacts each. The unit button was then pushed seven times, which stepped the wiper to the seventh contact in the fifth group. Following the general practice of the time, the bell of the called station was rung by means of a magneto attachment on the calling telephone. At the close of the conversation the third button was pushed. This operated the release magnet which freed the pawls and permitted the shaft and wiper to restore to the initial position. The performance of the functions just described necessitated the use of five wires from each telephone to the corresponding switch at the central office.

The switchboard installed at LaPorte although very crude marked a real advance in telephone development. The important point was that, contrary to general expectations, it worked. It not only proved its right to existence, but also demonstrated beyond doubt that the automatic system embodied revolutionary possibilities in the telephone industry.

In 1893, a 200-line system was installed in LaPorte, the same general type of switch being used but having two rows of contacts about the circumference instead of one. The wiper was mounted on a rotating shaft as before, but it was so ar-

ranged that it could be moved along a radial arm from one row of contacts to the other. In this way the hundreds could be selected. The calling device was the same as before except for the addition of another button for selecting the hundreds.

This general type of apparatus was installed in a number of cities in the United States, each installation representing a mechanical or electrical refinement on the preceding. It is true that the apparatus was crude in many ways. Today it would not be tolerated at all, but at that time crudities existed in all parts of the telephone field, and compared with manual equipment of the time, these early automatic switches had so many points of superiority that they won out and held the good will of all who used them. Although automatic switches of the above type were installed with a capacity of 300 and 400 lines and gave satisfactory service, it was realized that individual exchanges were destined to reach a size far beyond that limit. With this conviction the development workers turned their efforts to devising some other means of enlarging the capacity of the system. Instead of trying to make each switch of sufficient capacity to contain the line terminals of every subscriber in the exchange, it was decided to use primary and secondary switches, the primary switch operating to pick out the desired hundreds group and the secondary switch to connect with the called line.

The first installation of this type was at Augusta, Ga., in 1896, and had a capacity of 1000 lines. Each subscriber's line terminated in a primary or selector switch. The selector switches were of the "up and around" type, but had only one set of contacts in each of the ten levels. Each level of contacts was multipled throughout the entire group of selectors, and the wires from each level were led to a connector switch having access to the corresponding group of 100 lines.

Another important advance at this time was the change of the calling device from the push-button to the dial form. The first dial calling device consisted of a plate bearing ten finger vanes numbered one to zero. The plate was pivoted at its center so that it could be rotated in a clockwise direction against the action of a spring. To operate it the subscriber placed his finger on the vane corresponding to the first digit of the number, and rotated the dial until his finger struck against a stop. When the dial returned to normal, the "vertical" line was successively grounded a number of times corresponding to the figure dialed. At the same time a mechanical device attached to the dial caused the next operation of the dial to ground the "rotary" line instead. In a similar manner the third digit grounded the vertical line again.

Another interesting feature of these switches was the use of relays for operating the magnets. In all the former installations, the telephone lines were simply included in the magnet circuits. While this was fairly successful for short lines, the long lines found in Augusta necessitated the operation of the magnets by line-controlled relays. The operation of the switches was as follows:—dialing the first digit stepped the shaft and wipers of the selector switch up to the desired hundreds level. The second series of impulses came in over the rotary line. The first impulse rotated the wipers on to the set of contacts and the remainder passed to the vertical relay of the connector switch, the line wires between the two switches being reversed. The remainder of the second series of impulses now operated the vertical magnet of the conector and stepped the wipers to the tens level. The last series coming in over the vertical line operated the rotary magnet of the connector.

The Augusta plant marked a great step in advance in automatic telephony, for while the system as there installed had many limitations, particularly in having but one trunk in each group of 100 subscribers, the introduction of the idea of primary and secondary switches cleared the way for the development of automatic trunking, the next great move automatic telephony accomplished toward its more perfect state. It will be remembered that in the former automatic exchanges each subscriber had a switch of his own, but since the largest number of conversations possible was fifty per cent of the total number of lines, it is obvious that at least half

of the switches were idle at any time. On the other hand, in the Augusta plant, there were only ten connectors for the entire 1000 lines; and this was entirely too few. The proper number lay between, and as a result of a careful study it was decided that 10 per cent was entirely adequate to meet ordinary demands without undue waste of equipment. This, however, necessitated ten trunks leading from each level of the selector switch banks, each level of trunks leading to ten connector switches serving 100 lines. This proved to be one of the most difficult problems thus far encountered. The difficulty will be more clearly appreciated when it is understood that the selection of an idle trunk must be secured without any special knowledge of the system on the part of the subscriber.

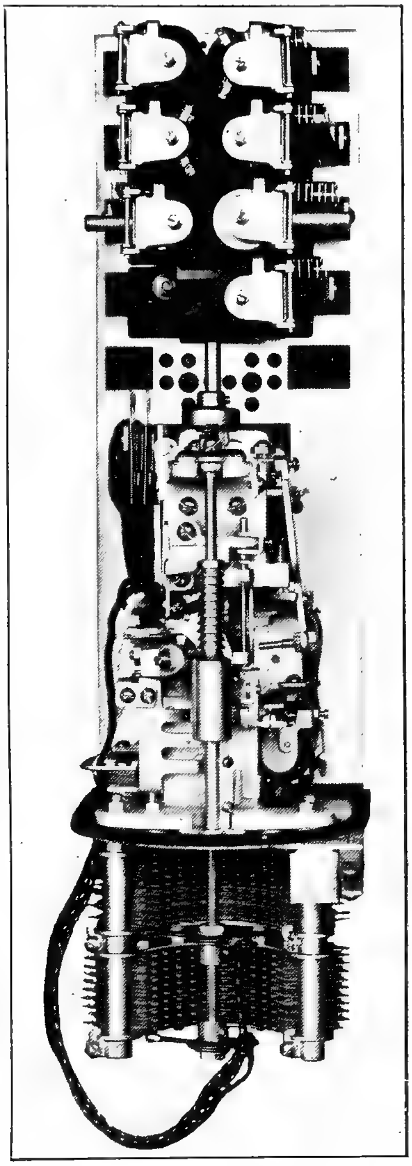
The first selector switches designed for this purpose had ten sets of contacts on each level. The problem was, after the first digit had stepped the wipers up to the desired level, to rotate the wipers until the contacts of an idle trunk were reached. This was first accomplished by inserting an "o" in each number after the first digit, and arranging the circuit so that the remainder of the ten impulses would be lost after the first idle trunk was reached. The next step was the development of the machine rotary. The circuit of the rotary magnet was taken through an impulse machine, and this was cut out of circuit when an idle trunk was reached.

It has been mentioned in the early part of this brief memorandum that the tendency of development in manual switchboards had been away from the idea of trunking between sections, and towards the multiple idea, in which each operator is able to complete connections directly to any line in the office. It will be noted in this connection that with automatic development quite the reverse has been true. So long as the automatic engineers tried to follow the full multiple idea, complete success was denied them; and the automatic system of today is essentially a system of trunking between groups. By means of these trunk connections, the calling line is extended a step at a time, first entering a large group, then choosing a smaller group, and finally entering into connection with the line itself. Thus in a system of 10,000 lines, the first digit dialed operates a first selector which steps up the wiper to the lever corresponding to the thousand group desired. The selector shaft immediately and without regard to the dial, rotates until the wipers rest on the contacts of a trunk leading to an idle second selector in that group. The second digit dialed operates the second selector in the same way to choose a trunk leading to an idle connector switch serving the particular hundred group desired. The last two digits cause the connector switch to seize the desired line and prepare the ringing circuit.

It will be interesting at this point to note the method used for guarding busy trunks and lines from intrusion. Associated with each selector and connector switch is a "private" bank of 100 single contacts similar to the banks of double contacts for line terminals. Mounted on each shaft is an extra wiper which moves so that when the line wiper rests on a certain pair of line contacts, the "private" wiper rests on the corresponding private contact. In a selector switch the electrical potential of the private contacts determines the trunk upon which the wipers shall stop; and when the wipers stop upon an idle trunk, the selector switch immediately replaces a guarding potential upon the associated private contacts to prevent any other selector from stopping on that trunk. The means taken to prevent a connector switch from intruding on a busy line is very similar. In this case, the busy potential of the line called causes a certain relay to operate, and places an interrupted buzzing tone on the calling line as an audible signal. Another great improvement introduced at this time was the substitution of push-button ringing for the awkward magneto.

These changes made possible a desirable improvement in the calling device also. The operation of the dial now served to ground the vertical line a successive number of times and this was always followed by a single impulse over the rotary line. The vertical impulses operated the vertical and rotary magnets of the connector switch, and the vertical magnet of the selector switch; while the single rotary impulse after each series operated a side or

pilot switch on each selector or connector, to switch the impulse from one magnet to the other. The release also was simplified. Hanging up the receiver caused the simultaneous grounding of both relays,



A Connector Switch

which operated the release magnet and restored the shaft to normal.

With the completion and successful operation of a number of exchanges of this type, the commercial development of the Strowger Automatic Telephone system may be said to have begun. Hitherto, the apparatus had, in a certain sense, been accepted on faith. It is true that until this time the automatic telephone apparatus had been somewhat defective, but it is also true that the defects were not inherent, and simply incidental to its incomplete development.

The next installation deserving of special mention was that installed in Los Angeles in 1904. This installation was important in that it marked the beginning of interchange of service between automatic and manual equipment. The problem of interchange of service had never been dealt with before, for it involves the adjustment of automatic apparatus so that it would fit into an already existing manual plant in such a manner as to involve a minimum of inconvenience and also the least possible expense of operation. Not only was this accomplished in a satisfactory manner, but the foresight of the men entrusted with the work prompted them to design the apparatus in such a way that when it became desirable to extend automatic operation to the entire system, the first installation fitted into the complete design without modification.

Up to this time the automatic engineers had, in accordance with the then prevailing practice, based the operation of the equipment upon the use of local batteries for energizing the transmitters. It has come to be generally recognized, however, that the most economical method of speech transmission lay in the direction of common battery feed to substations, and they therefore set themselves to the task of conforming to this progress. The system of battery feed finally adopted was that of the familiar condenser-impedance-coil system widely used in manual transmission. The circuit of the connector switch was redesigned so that the windings of two of the relays used in building up the connections served for battery feed coils during conversation.

The invention of the Keith line switch in 1906 was probably the most important of the factors which made for the wide adoption of automatic equipment in subsequent years. Up to that time, it had been necessary to terminate each subscriber's line in a selector switch, each being capable of a vertical motion and an automatic rotary

trunk-finding action. With the introduction of the line switch, a small group of first selectors was made common to a much larger group of subscribers. Each subscriber's line now terminated not in a selector switch but in a line switch, which, upon lifting the receiver, operated to extend the calling line directly to an idle first selector. The line switch, being entirely independent of the calling device, does its work in a fraction of a second, and before the subscriber has a chance to operate his dial.

A line switch consists essentially of a magnet, which upon energization draws a plunger into a bank of contacts, thereby closing the circuit of that line through to a non-busy selector switch. The line switches are mounted as shown in the illustration, in units of 100 each from which ten or more trunks run to as many first selector switches. All line switch plungers not in service are normally kept standing opposite the contacts of a non-busy trunk, and these plungers are kept aligned at all times by a master switch associated with each group of line switches.

Another important development occurring a little later than this was the substitution of an all-metallic line circuit for the ground return formerly used. In the so-called three-wire system, as before stated, each line wire was connected through its corresponding relay to negative battery. Grounding either line at the telephone caused the operation of the corresponding relay. The elimination of the ground return brought about the substitution of a single line relay connected directly across the two line wires at the switch. The circuit arrangement of the selector and connector switches was entirely redesigned. The operation of the vertical magnet was now secured by the successive interruption of the circuit of the line relay, while the operation of the side-switch depended upon a pause between two series of impulses. Probably the most important result obtained was a very desirable simplicity in the construction of the calling device. A good idea of a modern calling device may be had from a consideration of the accompanying illustration. It will be remembered that in the former system the operation of the calling device caused a number of impulses to be sent over the vertical side of the line followed by one over the rotary line. This necessitated a rather complicated mechanism of considerable bulk and involving frequent adjustments.

To operate the two-wire switches, however, it was only necessary to provide a number of successive interruptions of the line circuit for each figure dialed. The operation of such a switch depends upon the use of certain combinations of slow acting relays. A slow-acting relay is constructed by placing on one end of the core a heavy copper collar. When the circuit of such a relay is broken the heavy currents induced in the copper ring cause the armature to be retained a fraction of a second. The applications of the slow-acting relay in modern automatic telephony are many and varied, but its chief value lies in the fact that it may be kept energized by a series of rapidly recurring impulses of current.

An Automatic Desk Telephone

Coincident with the development of the two-wire system was the adoption of automatic ringing in place of push-button operation. Each connector switch is equipped with a ringing relay which operates when

the side switch passes to the ringing position. The circuit is so arranged that the bell of the called station rings intermittently until the calling subscriber hangs up the receiver. It is so arranged that the calling subscriber also actually hears that the ringing is taking place.

In the earlier days of the telephone art, service consisted of nothing more complex than the simple single party-line calling. With the progressive education of the public in the use of the telephone, demands have been made upon the various operating companies for particular kinds of service. It happened, therefore, that as soon as the Strowger Automatic telephone system had reached a point where the fundamental problems of operation had been solved, automatic development workers were called upon to turn their attention to modifying their established designs to take care of special requirements.

The operation of party lines, private branch exchanges, measured service devices and the various other features characteristic of modern telephone service have presented many complex problems. The very nature of the automatic system is such that it is impossible to resort to the "human factor" to secure any desired results. Everything has to be performed mechanically and without imposing any added burden upon the subscriber. Probably the first problem to be solved was that of giving party-line service. This has been solved to the point that today it gives the subscriber who has but a limited use for his telephone, facilities in every way adequate to his needs.

Each party line has but a single line switch for outgoing calls, but it is served by a number of groups of connector switches. Full selection is secured by the use of harmonic ringers, that is, the bell of each station on the party line is tuned to respond to a different frequency of alternating ringing current. The party lines are grouped together on switchboards separate from the single party lines, and each board is provided with one group of connectors for each frequency used. Each subscriber's line is multipled to the banks of all these connectors. Thus a four-party line board is equipped with four groups of connectors, each connector having access to every line in the hundred, and each group being supplied with a different frequency of ringing current. The hundred digit of the call number selects the group of connectors, and therefore fixes the frequency which shall be used. The last two digits control the vertical and rotary motions of the connector as usual. Any group of connectors can equally well connect the desired line, but the bell which rings depends upon which group of connectors is used. It will be seen that no modification is necessary in the circuit or mechanism of the switch, the selection of the frequency being cared for in the trunk connections between the selectors and connectors.

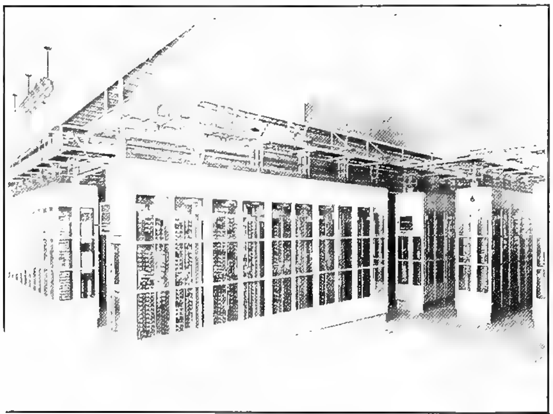
An alternate method is to have but one group of connectors, each connector being equipped with some form of frequency selecting device operated by an additional digit in the call number. In this case, the line is selected first and the frequency of ringing current or the particular station on the line is then determined by the final digit.

Calls between parties on the same line are also taken care of in a satisfactory manner. At each station on a party line is mounted a card showing the directory numbers of the other parties on the line and the proper reverting call numbers to be used to reach each one. Dialing such a number connects the line to a reverting call switch. The calling subscriber now hangs up his receiver and immediately the bells of both called and calling parties begin to ring intermittently. When the call is answered, the ringing stops and conversation can proceed. All the switches used in starting the ringing except the first selector now restore to normal.

It often happens that a business house or other large institution requires several trunk lines leading from the private branch exchange to the central office and still desires only one directory number. To care for this need, a special form of connector switch has been developed with an automatic rotary feature. For example, if the subscriber needs say, six trunks, he will be assigned six lines whose actual numbers are consecutive and whose connector bank contacts are on the same level. The directory number to be used

in calling this subscriber will be the actual number of the first line. If this number is dialed and the first trunk happens to be busy, the connector wipers will immediately pass to the next trunk, and only when all trunks have been found busy will the wipers come to rest and send back the busy tone to the calling party.

The demand for measured service de-



A General View of an Automatic Telephone Exchange

vices in telephony has also been answered by the remarkable flexibility of Strowger Automatic equipment. Call-counting devices were used on some of the earliest installations. The circuits are now so designed that the service meter records all effective calls but disregards all calls attempted when the line is busy, or when no reply is received. Calls for special services such as fire and police, information, etc., are not recorded.

Automatic pay stations for intermittent telephone users have been in successful use for a number of years. A patron calling from such a telephone lifts the receiver from the hook and operates the dial as usual. When the called party answers, the connector switch operates to reverse the polarity of the battery on the calling line. This places a shunt around the transmitter of the calling station until the coin is dropped; when the transmitter is mechanically freed.

Special equipment of the Strowger type has been developed for long distance switching, rural line service and exchanges for small communities. But in a brief review such as this, particular mention of these types need not be made.

In a word, it may be conservatively stated that the Strowger Automatic Telephone system stands today as a completely developed equipment, whose ability to meet any and all telephone requirements has been fully proved by over a quarter of a century of operation under every conceivable service condition.

This system has been studied, endorsed and installed by the governments of many foreign countries and is being widely adopted by the largest operating companies in the United States. Telephone engineers and experts throughout the world recognize the fact that automatic telephone operation is destined to displace all other methods just as rapidly as the equipment can be produced and installed, and they see in the Strowger type the equipment which has demonstrated its ability to meet all needs.

JOSEPH HARRIS

The remarkable record that the Strowger Automatic Telephone equipment has made in the history of the telephone art is due primarily to the keen foresight and economic vision of Mr. Joseph Harris, who in 1889 volunteered to undertake the development of this apparatus. Mr. Harris was born and raised in Chicago and educated for a commercial career. He had the additional advantage of training in sound business principles received through his father, one of Chicago's pioneer wholesale merchants.

Mr. Harris' connection with the Automatic telephone dates from 1889, when in the course of a business trip through Missouri and Kansas, he came in contact with Mr. Almon B. Strowger, an undertaker of Kansas City. Mr. Strowger's mind was full of a vision of a telephone system free from the annoyances and delinquencies of switchboard operators. With the enthusiasm of an amateur experimenter, Mr. Strowger directed the attention of Mr. Harris to a mass of drawings and a crude model of an automatic telephone and switch. With his wide business experience Mr. Harris probably had a clearer realization of the shortcomings of manual telephone systems than the inventor himself, and he at once perceived great possibilities in this crude invention. He foresaw that the limitations and restrictions incident to manual telephone switching would sooner or later necessitate machine connections, and that the mere human mechanism would have to be eliminated as in so many other fields of advance.

It was chiefly through Mr. Harris's own efforts, and largely because of the esteem in which he was personally held, that a company known as the Strowger Automatic Telephone Exchange was formed, with Mr. Harris as secretary; and active steps were taken to make the idea a reality.

It was no light task which confronted the men who thus undertook the development of the Automatic telephone. Aside from the technical problems involved, there were the even more difficult problems of making the venture from the beginning a commercial success. It was in this direction that Mr. Harris' chief talent lay, and to these problems he applied himself. Mr. Harris' efforts appear all the more remarkable when it is considered that his confidence remained unshaken amid the scorn of many whose opinions in other matters carried weight.

It was not until November 1, 1892, that the patience and fortitude of Mr. Harris received its first reward. With the

JOSEPH HARRIS

installation and successful operation of the first public Automatic Exchange in LaPorte, Ind., began the growth of the Automatic movement. Realizing the crudities and limitations of the early apparatus, Mr. Harris gathered about him a group of men whom he inspired with a confidence equal to his own, and delegated to them the duties they could best perform, resolutely refraining from hampering them in the performance of their work by any insistence upon his own opinions as to details. With the help of these men, Mr. Harris was able to profit by the mistakes and failures of the early years and turn them into the successes of the present.

In 1901, Automatic Electric Company was organized under the laws of Illinois, with Mr. Harris as president, in which capacity he continued until June, 1919, when he retired as president, but has continued in active connection with the business as chairman of the board of directors.

Despite his close and uninterrupted attention to a single line of activity, he has not been narrowed by this course. His business relations have been supplanted by strong friendships among those with whom he has dealt, and his official duties have been accompanied by private interests which have brought him in close touch with the social life of his home city, so that besides being one of Chicago's leading business men, he has long been recognized as a public spirited citizen of broad sympathies.

The development of telephony has brought fame to many, but when the history of the art is finally written, the name of Joseph Harris will be recognized as that of leader and pioneer.

ALEXANDER ELSWORTH KEITH

The Automatic Telephone system stands as an enduring monument to Mr. Alexander Elsworth Keith, for 28 years head of Automatic Electric Company's engineering staff and inventor of many of the features of the present Strowger Automatic telephone equipment. Mr. Keith was born in Baltimore, Md., in the early 60's, and after a comparatively brief formal school training, he began his career as messenger boy. Advancing from this to a position as telegraph operator, he began the study of the subject which was to hold his attention throughout the rest of his life. Studying electricity with a zeal that was characteristic of his later work, he was able to fit himself for more important work than that of telegraph operating, and when only about 25 years old he was sent to Venezuela by an American syndicate to take charge of the installation of the first telegraph and telephone lines in that country.

ALEXANDER ELSWORTH KEITH

Returning from South America after some years, he was retained as mechanical and electrical expert by the Brush Electric Company of Baltimore. At that time Mr. Joseph Harris, secretary of the Strowger Automatic Telephone Exchange, was undertaking to form an organization in Baltimore for the exploitation of the Strowger system and in doing so came in contact with representatives of the local Brush Electric Co., who at once became interested. They accordingly assigned to Mr. Keith the work of investigating and reporting upon the Strowger apparatus.

Having worked upon an automatic telephone system of his own, Mr. Keith was well able to appreciate the possibilities of the apparatus he was sent to inspect. He was so favorably impressed, that after completing his investigation and making his report, he resigned his position with the Baltimore Brush interests and entered the employ of the Strowger Automatic Telephone Exchange. He has devoted himself uninterruptedly to automatic telephony since that time.

CHAPTER IX

INDEPENDENT TELEPHONE ORIGIN AND THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY

THE history of the Stromberg-Carlson Telephone Manufacturing Company dates back to the beginning of the "Independent" telephone movement in the United States. It is now one of the leading telephone manufacturing industries in the country, and stands as an eloquent monument to the visions and tireless efforts of Alfred Stromberg and Androv Carlson. Back in 1870 Alfred Stromberg started his electrical work with Mr. L. M. Ericsson, the well-known European telephone inventor and manufacturer of Stockholm, Sweden, and continued with him for nine years. In 1879 and 1880, when the Ericsson Company began to erect telephone exchanges in Sweden, he took charge of the installation department, and this work was later carried on in Denmark. He assisted also in the testing of the first pair of telephone instruments that the American Bell Telephone Company sent to Stockholm, Sweden.

In 1885 he came to the United States and located in Chicago; entering the employ of the Chicago (Bell) Telephone Company, he worked in their instrument department for five years. During this time he made a number of important inventions, some of which are still used in a modified form in the Bell system.

Upon resigning from the Chicago Telephone Company in 1890, Mr. Stromberg took charge of the practical work of the Chicago Electrical Protective Company's burglar alarm system. Here again he made not only improvements but inventions, some of which are in use today.

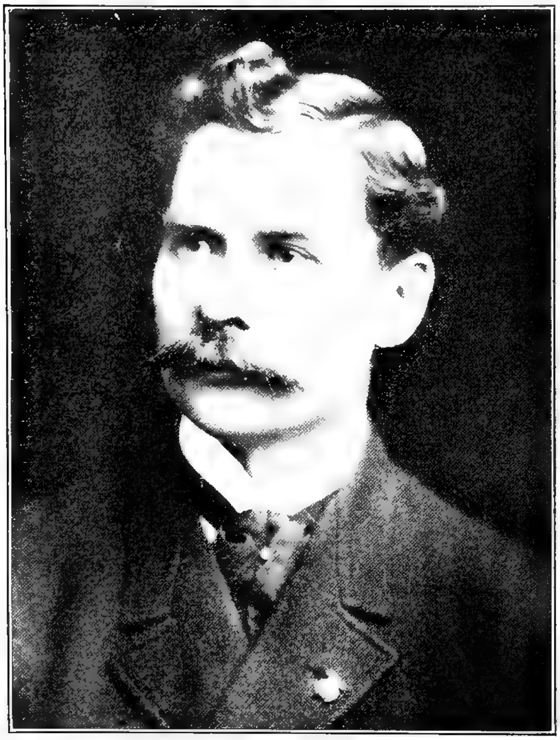
In the 80's Androv Carlson also entered the employ of the Chicago Telephone Company and was assigned to the repair department, wherein he had full charge of the repairing and rehabilitating of all returned instruments. While in that employ, together, Stromberg and Carlson formed an acquaintance which later developed into their business association.

Telephone service from its inception and up to the beginning of the 19th century was a luxury enjoyed only by those able to afford it. At that time the fundamental patents of the telephone industry were controlled by one corporation which met the demands of the important cities and towns with a service then and still known as the Bell System. At the expiration of the Alexander Graham Bell patents Nos. 17465 and 186787 in 1893 and 1894, the way was open for general telephone development, free from those two "controlling" patents.

The last few years of the 19th century showed that the convenience of the telephone had become recognized by the American public; that the demand for service had become so great that the system then in control was unable to meet it,

and that this demand had already attracted men of inventive ability and of the pioneering type. Realizing the opportunity and feeling confident that they could develop equipment that would not infringe existing patents, Stromberg and Carlson decided to launch into business for themselves and, accordingly, in 1894, opened up a small shop in the Springer Building in Chicago, Illinois.

Their first activities were the invention



ALFRED STROMBERG

of a transmitter and receiver along Swedish lines, which successfully evaded existing patents. The transmitter consisted of carbon granules in a plush ring connected with gold screen electrodes. Its success was, without a doubt, due to the skill and care used by Carlson in its manufacture.

The receiver was of the bi-polar magnetic type, having an adjustable diaphragm and an enclosing metal head with a rubber shell casing and with concealed binding posts. These two fundamental parts were considered marvels at the time, as they were extremely sensitive and reproduced the human voice perfectly. Furthermore, they not only talked loudly and clearly, but were substantial. Around these two important pieces of telephone apparatus, the two men built a complete telephone set and later their entire system. Their development at first was confined to "magneto" telephones.

The American farmer had now discovered how practical the telephone was and how simple to install and operate; and immediately the farm telephone development began by leaps and bounds. Then as the farmers were able to talk back and forth on their own private lines, the demand arose for coöperative interconnection and Stromberg and Carlson produced switchboards to meet the demand. Their business increased so rapidly that in 1895 Stromberg and Carlson incorporated as the Stromberg-Carlson Telephone Manufacturing Company, under the laws of Illinois, with headquarters at Chicago. In 1896 they moved into larger quarters, taking the east half of the first floor and basement of the Dunn Building on the corner of Jackson Boulevard and Clinton Street, Chicago.

Stromberg with his characteristic enthusiasm and energy was the business mainspring of the company, while Carlson was the production factory man and particularly watched the development of the transmitter and receiver, which, after all, are the heart and soul of the telephone. These two men at this period and all through their business career displayed really marvelous ingenuity in designing equipment that contained original ideas, and yet which was free from existing patents owned by any others. During the early life of the company, the main efforts were directed to the farm line system, and the company grew with true Western celerity. For example, starting in the Dunn Building as stated with the first floor and basement, they rented floor after floor as their business grew, and finally in 1901, purchased the entire seven-story building together with a four-story annex on Clinton Street.

Magneto switchboards had passed through the development stage first with ringer to drop signals, then to generator call indicator signals, later refined to battery lock-up indicators, next to signals automatically restored by the operator plugging into the answering jack. The present type of combined tubular drop and jack

with code call and mechanical plug-restoring features was not developed until much later. The connecting cord circuits likewise had passed through even a greater series of changes, all tending to improve the supervision on the part of the operator so that the connecting parties could promptly attract the attention of the operator.

It is well to note that during the period 1895 to 1900 the demand for telephone service had become so great, and so few knew anything at all about operating telephone equipment, that it was necessary for the Stromberg Company's men to assist in the organizing and incorporating of local telephone companies as well as to do the complete engineering of the plant, the manufacture and installing of the apparatus, and to teach the telephone company, often composed of inexperienced men, how to carry on its business and maintain the equipment up to a desired standard.

About this time the demand for telephone service in the large cities led to the modern centralized battery type of equipment. As the demand for centralized battery systems for larger centers grew, the Stromberg Company produced a "Central Energy System"; all battery power being located at the central office and, consequently, doing away with the batteries that the various single telephones contained at the subscriber's station and likewise doing away with the telephone hand generator.

The first central energy board was of the visual signal transfer type and was built in 1897. Each section, usually of 100 lines, was complete in itself. Connection between subscriber lines terminating in one switchboard section with lines in another section, not adjoining, when more than two sections were installed, was accomplished by means of transfer circuits. The visual signal type of switchboard was produced in multiple form in 1898. By this time the Stromberg line of production had grown to be very comprehensive and they were able to produce large central energy multiple exchanges that were even in advance of the times. Many large plants had been built and were operating.

In 1899 the Home Telephone Company of Rochester, N. Y., entered into a contract with the Stromberg-Carlson Telephone Manufacturing Company for their Stone Exchange. After waiting what they considered a reasonable length of time for delivery, representatives of the company were sent to Chicago to find out why their equipment was not shipped and were amazed to find such a large, busy factory with such a future before it.

ANDROV CARLSON

The Rochester men, feeling that to be assured of a source of supply they should control it, decided that the proper place for the Stromberg-Carlson Company was in Rochester and immediately set out to re-finance it and move the plant to Rochester. They were successful in their efforts; 1902 saw the Stromberg-Carlson Telephone Manufacturing Company reorganized under the laws of the State of New York, and in 1903 it was well established in splendid new quarters, located at the corner of University Avenue and Culver Road in Rochester, New York. To the already large business, a cable plant was added and the phenomenal growth continued.

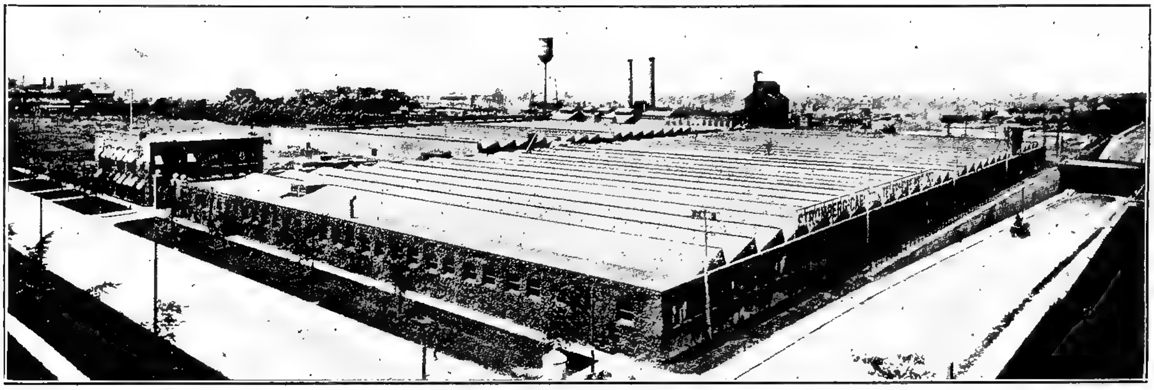
In 1900, lamp signal switchboards were introduced, and this led to the in-

stallation of many large multiple switchboards, including the following: Minneapolis and St. Paul as well as Duluth, Minn.; Kansas City, Missouri; Louisville, Kentucky; Rochester, Utica and Syracuse, New York; Salt Lake City and Ogden, Utah; Seattle, Washington; Boise, Idaho; Waco, Texas; Fort Wayne and Terre Haute, Indiana; Birmingham, Alabama; Atlanta, Georgia; Des Moines, Iowa; Memphis, Tennessee; Toledo, Ohio; Wheeling and Parkersburg, West Virginia. In 1905 they built and erected in St. Louis, Mo., what was at that time and for many years after, the largest single multiple lamp signal switchboard installed.

In 1910 the Stromberg-Carlson Company took over the tools, shop rights and patents on all the central energy telephone business of the American Electric Telephone Company of Chicago, Illinois. Later, in 1916, the Stromberg-Carlson Company took over the patents, tools, telephone business and telephone organization as well of the Garford Manufacturing Company of Elyria, Ohio.

The Garford Company had been a prominent factor in the "Independent" field and had built and installed many large multiple switchboards, the largest being the famous Detroit Main Exchange. In fact, it was in itself a consolidation of several telephone manufacturing companies, including the Rawson Electric Company and later the Dean Electric Company, both of Elyria, Ohio; the Sumter Telephone Manufacturing Company of Sumter, S. C., and the Eastern Telephone Manufacturing Company of Harrisburg, Pa.

The apparatus that had been manufactured by these companies has all been successfully merged with the Stromberg-Carlson Company's line, and this consolidated business is now very extensive and is world-wide in scope. In other words, Stromberg apparatus can be found in practically all the countries of the world; and in addition to its own export travelers, the Stromberg Company has substantial business connections in the more important countries.



The Plant of the Stromberg-Carlson Telephone Manufacturing Co. at Rochester, New York

The Stromberg-Carlson Company has been a pioneer and a leader in many respects, and has produced equipment that at all times has been in step with its leadership of the development of the art. Some of its important advances that stand out are described below.

It was the first company to pay attention to mounting apparatus in switchboard cabinets so as to be accessible. Originally, relays, repeating coils, condensers and operator's circuit equipment, were mounted with apparent disregard for maintaining the equipment after the switchboard was installed.

In the early switchboards, it was necessary for the maintenance man to disturb the operator in getting at most of this apparatus, as panels had to be removed from the front of the cabinets to reach vital portions of the equipment. Realizing through its customary close association with the operating companies the necessity of helping

them solve operating and maintenance difficulties, the Stromberg Company was quick to adopt schemes which would overcome such defects in switchboard design. Apparatus such as repeating coils and condensers were soon designed to mount on metal plates similar to relays, and later all of this apparatus was assembled on swinging relay gates, so that the maintenance man could get at both sides of the apparatus from the back of the switchboard and without disturbing the operator.

Another advantage of this swinging relay gate was the placing of more of the switchboard apparatus in the cabinet than was heretofore the standard practice. This resulted in economies in wiring and greatly simplified the maintenance. In the standardized Stromberg P.B.X. switchboards, this accessibility has been further improved by mounting the trunk circuit apparatus on removable plates, which allow extensions or replacements to be made without the use of soldering irons.

Four-relay cord circuit, developed by this company, is the fundamental cord circuit used in the "Independent" telephone field today.

As four-party line service was developed, it was found necessary to have a key that would show the operator which subscriber had been rung last and the Stromberg-Carlson Company met this need by the development of the four-party, plunger type, indicating key. Until recently this has been standard on all modern party line manual boards.

The requirements for telephone service underground in mines resulted in the development of the first iron-clad, moisture-proof special mine telephone, which is purely a Stromberg product.

The bridge type of sub-station circuits for use in central energy telephone systems was also a product of the Stromberg-Carlson Company.

Next, its organization was responsible for the first commercial two-gong harmonic party line telephone. Then followed the first harmonic converter ringing machine, which practically revolutionized selective ringing and made possible the present extensive use of the four-party bridged selective ringing system.

The first instantaneous disconnect manual cord circuit, which made it possible for a talking subscriber to sever the talking circuit at the switchboard and institute another call without requiring the operator to take down the first connecting cord circuit was developed by it.

Another development was the first small-size, but highly efficient relay, which effected great economies in mounting space, operating and first cost.

It is generally conceded that the Stromberg organization also developed or marketed the first removable lever switchhook. This type of hook allowed the telephone to be packed for shipment in a more compact shape and thus avoided injury to the internal mechanism. It is now used by most manufacturers of telephone apparatus.

The demand for a disconnect signal on the key shelf for a magneto switchboard, that would function similarly to the disconnect signal on a central energy system, was met by the Stromberg Company in the development of the famous 169 key, which mechanically restores the two associated disconnect signals, when the operator throws the listening key forward to answer a call.

During the Great War, the Stromberg Company led in standardization work under the War Service Board, and apparatus models were quickly reduced to necessary types. As a consequence, untold good was done to the telephone industry.

During this period the first standardized stock magneto switchboard was developed on which every cord circuit was of a universal type, allowing interchange of connections between the different types of lines found in the country exchanges today, and containing the key type double clear-out signal in the key shelf and line signal code alarm drop. These boards were so designed as to be built and carried in stock, and packed securely and ready for shipment—an ideal arrangement believed impossible previous to that time. In like manner the Stromberg-Carlson Company developed the standardized stock private branch board containing a removable type of circuit plate which allowed adaptation to different classes of service.

One of the latest developments of this

company is the master key selective ringing system, which was first installed and is now in operation at Fort Wayne, Ind., and in which each key shelf possesses but a single four-button key for a plurality of cord circuits. This scheme allows more calls to be completed in a given time by the operator and with less fatigue.

The Stromberg Company was the first to manufacture and use in the United States the combined receiver and transmitter telephone, known as the combination phone or micro telephone.

The Stromberg Company also developed many unique features in the art of switchboard construction for better handling of increasing telephone traffic, among which was the installation at Knoxville, Tennessee, in the year 1912. The fundamental principle of this installation was a lamp call distributing system, in which the traffic was uniformly distributed to the idle operators by means of an automatic relay-controlled call order wire scheme. This produced quicker answering time, and more uniform service, as well as making an economical reduction in the operating force.

A further application of this system was made at Louisville, Ky., in which the lamp call distributing equipment was principally used to handle the overflow traffic. It also facilitated the handling of the Sunday and night loads with a very much reduced operating force. Later were produced the "concentrated lamp signals," where each line lamp with an associated jack is concentrated in one or two standard switchboard sections in the face equipment. These features were added to the switchboards in modern exchange installations such as Dixon, Ill., Oil City, Pa., and Fort Wayne, Ind. For the smaller exchanges the value of this ingenious arrangement resulted in the associated lamp signal multiple switchboard, which is standard today, ideal in economy of operating, and has improved the handling of telephone traffic.

A particular advance in the method of handling the problems today in traffic and operating practices has been developed by the Stromberg Company in the cord circuit equipment installed at Fort Wayne, Indiana, Oskaloosa, Iowa, and Mt. Vernon, Washington. This has revolutionized the former type of switchboard and affords a higher standard of efficiency and economy than any other known method of telephone exchange switching. The fundamental principle of this cord circuit retains the same basic four-relay system which played such an important part in the cord circuit design developed by independent manufacturers. Additional features in this circuit were incorporated as labor-saving devices for the operators, permitting connections to be established with minimum physical effort. These improvements as follows: machine ringing which relieves operators of all manual ringing operations; flashing recall which regains the operator's attention by an intermittent flashing signal on an established connection so as to promptly serve a subscriber's line that is plugged up and requires reattention; keyless listening which eliminates entirely the use of a listening key; operator's bar; advance plugging-in; operator's listening indication; operator's secret service; monotone ringing indication; instantaneous ringing-cut-off; calling subscriber's ringing control; call registration; emergency ringing; and a master-key-controlled party line ringing by means of relay selection, which eliminates individual ringing keys per cord circuit. These later developments in the art of switchboard construction are, it is asserted, by far more ingenious and helpful in advancing the art than any of the other early achievements in the recognized standards of telephone exchange switchboards.

CHAPTER X

ELECTRICITY IN THE MINING OF COAL

JEFFREY MANUFACTURING COMPANY

THE manufacturing of electrically operated mining machinery is one of the important new industries that has developed in an inconceivably short time. The history of coal cutting machines had its beginning about the year 1876. At that time the total production of coal in the United States was about 53 million tons per year. The production of coal today is about ten times as great. This enormous tonnage could not be produced by manual pick and shovel and animal haulage, which were all the facilities available 45 years ago.

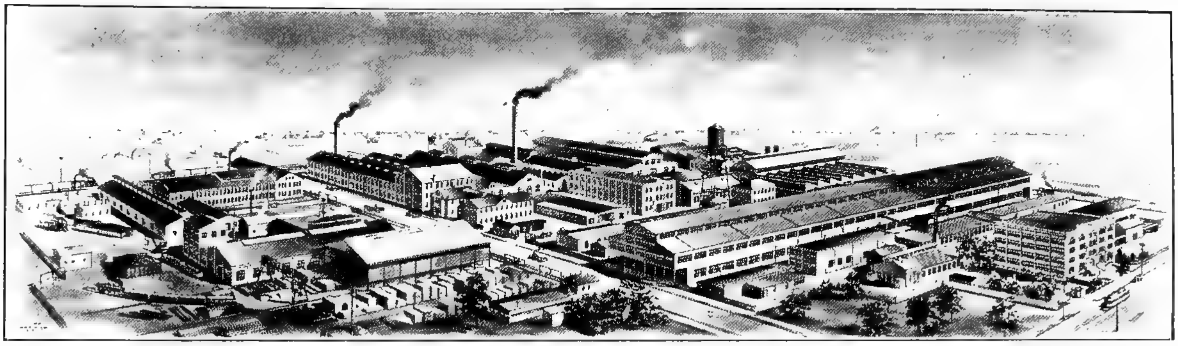
The tremendous advances made for the comfort of mankind in the latter part of the Nineteenth Century, such as railroads, steamships, street cars, telephones and telegraphs, better and more abundant clothing, houses with sanitary conveniences, farming machinery, etc., all required an ever growing number of factories, and these factories demanded more coal. "Necessity is the Mother of Invention," the need of machinery to produce the coal was evident, and inventive minds in various parts of the country began to study the problem and to design the machines.

Of the pioneers in the coal mining industry the Jeffrey Manufacturing Company is the most noteworthy, as it has grown in this comparatively short time to be the largest producer of coal mining machinery in the world. Several inventors tried to build a machine or two, but generally failed because they were often impracticable, unable to design useful machines which incorporated their ideas, so that practical results were not obtained unless men with judgment, experience, courage and unshakable faith in the ultimate success came to their assistance. Mr. J. A. Jeffrey, a banker of Columbus, Ohio, had brought to him the wooden model of a coal cutting machine. He saw the urgent need of such a device, and although the scheme was absolutely untried, and there was no precedent to judge by, he had the courage to go into this new enterprise whole-heartedly and to continue regardless of the innumerable failures which were inevitable, and in spite of opposition and prejudice on the part of the men at the mine, as well as mine officials and owners. Even after the machines had proven themselves practical and economical, it was found necessary to install them at the Jeffrey Company's expense, and charge so much per ton for cutting the coal.

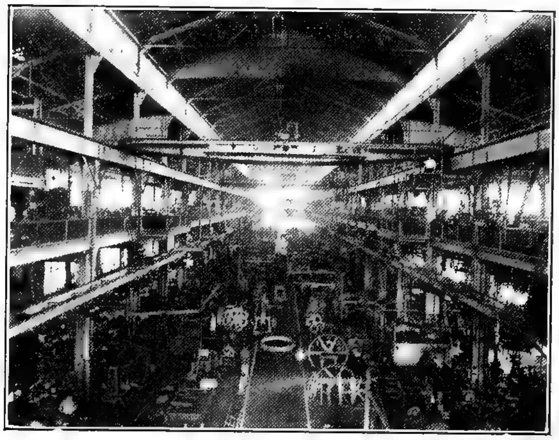
The first machines were worked out by the inventor, Mr. Lechner, and part of the work was done in a small shop located on the site of the present Columbus, O., Post Office. Later this shop was taken over by Mr. Jeffrey and was called the Lechner Machine Company. About 1884 this site was sold, and a small factory built on West State Street. The type of machine built at that time was known as the "Cutter Bar" and was provided with horizontal compressed air engine. A few of these

machines were furnished to Johnson Brothers and the Jobs Coal Company in the New Straitsville, Ohio, district.

The Jeffrey Company continued in business on West State Street until 1888, at which time the first shops were built on the present site, which was then a pasture field. The first three shops built were the blacksmith shop, pattern shop and chain shop; they covered four acres of ground.



Bird's-Eye View of Exterior of Present Plant of Jeffrey Manufacturing Company, Columbus, Ohio

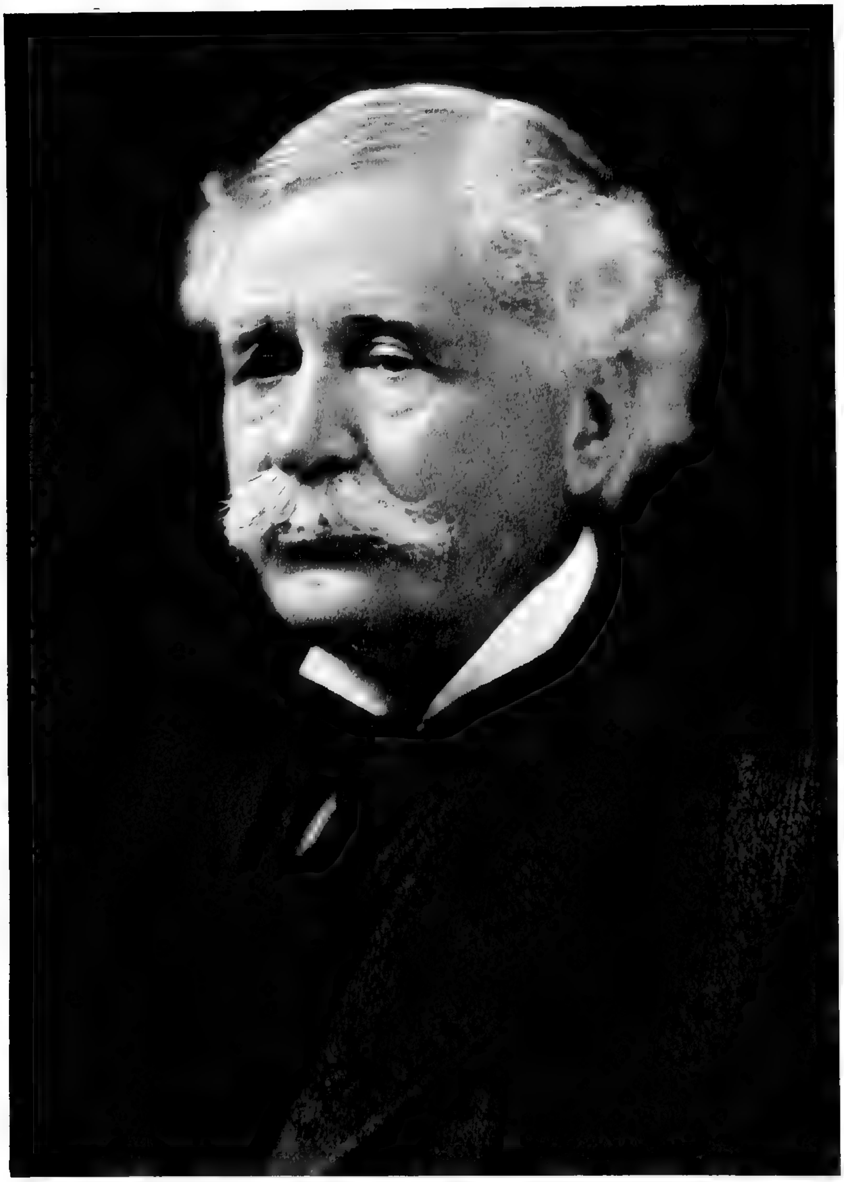


Interior View of Large Machine Shop of Jeffrey Manufacturing Company

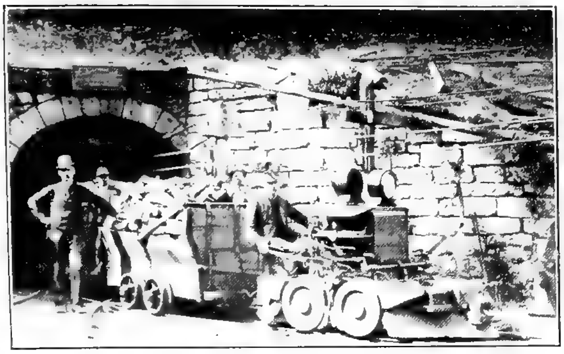
Mr. Jeffrey was fortunate in having associated with him almost from the very beginning Mr. H. B. Dierdorff, a man of unusual ability who was able to take the crude ideas of inventors and design practical machines, and at the same time organize an efficient factory organization. He surrounded himself with the best mechanics obtainable, many of whom occupy important positions with the company today.

The hardest labor in a coal mine is the undercutting of the coal preparatory to blasting. A man had to lie on his side and cut it out with a hand pick. Hence, the first machine brought out by the Jeffrey Manufacturing Company was a tool to do this work. It consisted of a horizontal bar about three feet long, having rectangular holes and set screws for holding the removable cutters. The bar was held in a suitable frame, revolved at a fairly high speed, and forced into the coal, thus cutting the kerf in the bottom of the coal seam. The first machines were driven by compressed air engines until about 1888, when the use of electrical power had been developed to such a point that it was considered preferable to compressed air. In the beginning of their electrical era the Jeffrey Manufacturing Company built their own generators and installed complete power plants, wired the mines, and built their own electrical equipment for the mining machines. It was not long before the electrical industry had so advanced technically that mine owners could obtain suitable power plants from firms specializing on such work.

In developing the electric motor for use on the coal cutter, it was suggested that one of these motors be fitted to a mine car to be used as a locomotive. Accordingly one of the coal cutter motors, having a capacity of approximately 15 horse power, was used in building one of the early mine



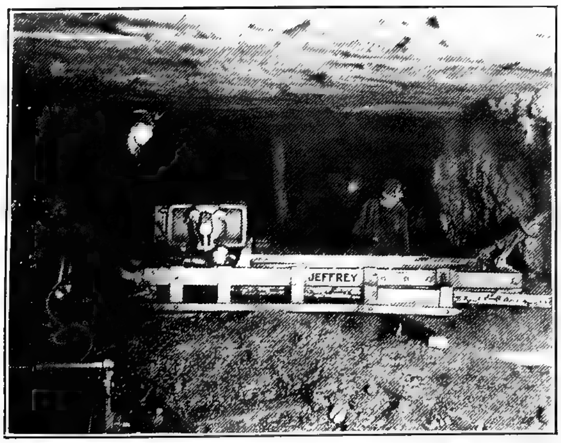
J. A. JEFFREY



The First Jeffrey Mine Locomotive

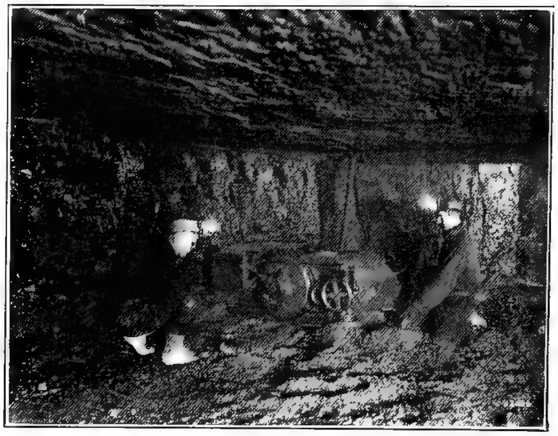
locomotives. From that time on, the manufacture of electrical locomotives developed rapidly. In 1889 the Jeffrey Manufacturing Company built their first electric locomotive, probably the first locomotive ever used in a coal mine. This locomotive was equipped with a 15 horse power bi-polar motor and weighed three or four tons. It was a success from the beginning as it replaced six mules. The trolley consisted of two ¾-inch galvanized iron pipes, one placed above the other.

In 1894 a coal cutting machine provided with a chain carrying the cutters was developed, and proved to be more efficient than the cutter bar machines. From that time on, all of the coal-cutting machines built by the Company have been of the chain type. The first of these coal cutters manufactured were breast type machines. These machines are provided with an undercutter frame which carries the cutter chain. The machine is jacked down to the bottom and the cutter frame fed into the coal face, making the cut about 3 feet wide and from 5 inches to 7 inches deep. The machine is then moved over the width of the cut, jacked down, and another cut made, and so on until the entire face is undercut. Several sizes of these machines were made having motors ranging from 12- to 35-horse power.



Breast Type Coal Cutter

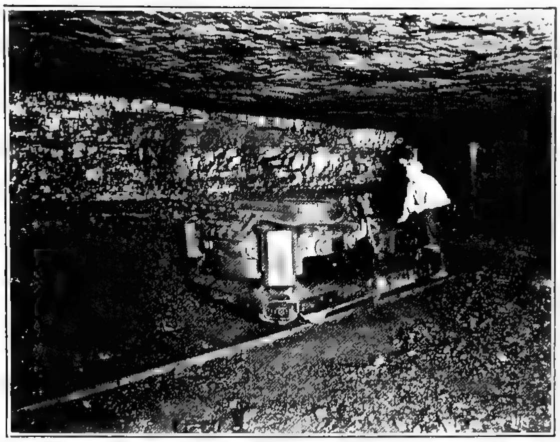
The developing of a suitable chain for the coal cutter together with demand for various types of chain for use around coal mines was partly responsible for the extensive line of chains and elevating and conveying machinery now supplied by the Jeffrey Manufacturing Company.



Shortwall Coal Cutter. Latest Type of Shortwall Machine

The machines were improved from year to year, but the "Breast" machine types remained the standard coal cutting machines up to about 1908, when the "Shortwall" type machines were introduced. These machines are provided with a chain and a cutter bar. The cutter bar is forced into the coal by means of steel ropes fastened to anchors. When the cutter bar is under the coal the machine is bodily pulled along the face, making an undercut. The "Shortwall" machine has become more popular each year, and to-day very few "Breast" machines are being sold, although there are thousands of them still in daily operation.

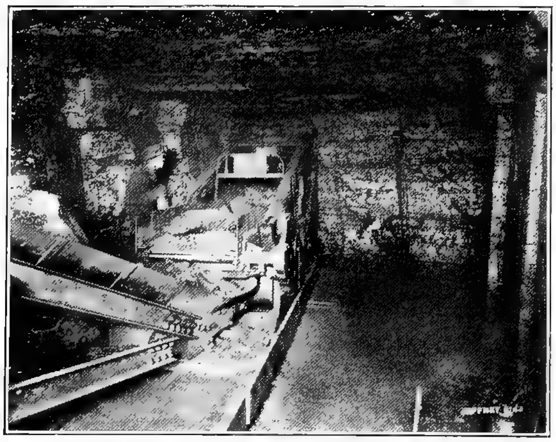
In 1908 a new type of coal-cutting machine was originated by the Jeffrey Man-



Jeffrey Arcwall Coal Cutter

ufacturing Company. This machine cuts in a circle and is therefore called the "Arcwall" machine. It remains on the truck while cutting. The truck is located in the center of the room and the machine and cutter bar is swung around on a turn table making the cut. The machine can be built with the cutter bar placed at any height, so that dirt seams can be cut or the coal can be cut at the top or bottom as may be required.

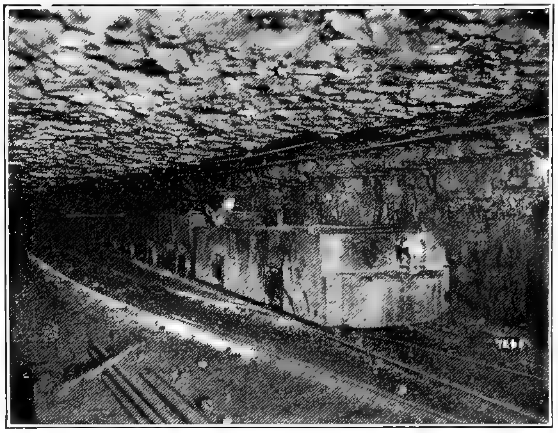
The "Arcwall" machine will cut from two to four times as much coal as a Breast or Shortwall machine. The reason for this is principally that the Arcwall machine is not unloaded from the truck on which it is transported from one place to another, but on arrival at the coal face is immediately ready to work.



Jeffrey Coal-Cutting and Loading Machine, Licensed under Patent of E. C. Morgan

The next hardest labor in a coal mine after undercutting done by hand, is the loading of coal. The Jeffrey Manufacturing Company as well as many others have developed loading machines, but so far they have not been wholly a commercial success, due to the inability of the mine management to supply the loading machines with cars to load in, and coal undercut and shot down ready to load. Regardless of the ability of the loading machines to load coal rapidly, and their reliability, they have not been a success, due to mine delays.

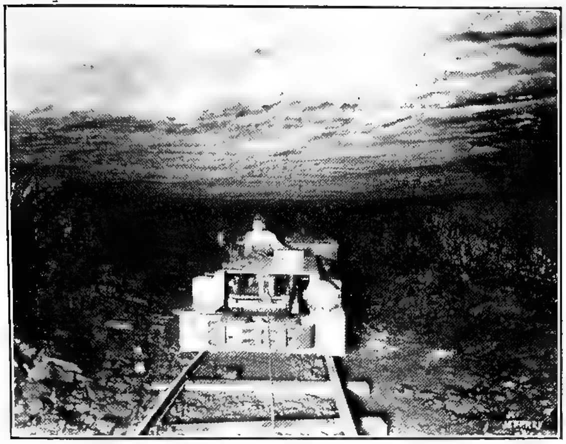
One of the latest machines developed by the Jeffrey Manufacturing Company is a machine licensed under the patents of E.



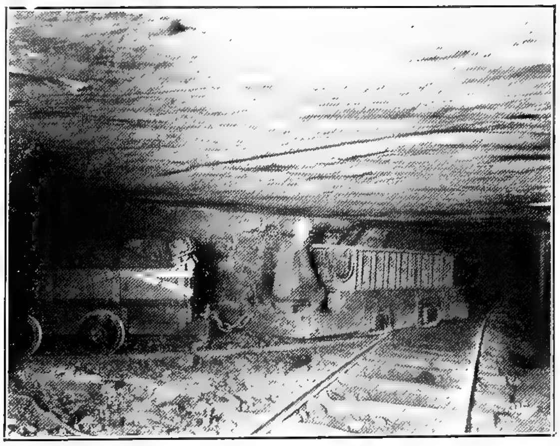
"Armorplate" Type Main Haulage Locomotive

C. Morgan—that mines and loads coal without the use of explosives; the coal is undercut, sheared, knocked down and conveyed back to the coal cars. The machine feeds into the coal much after the manner of a Breast type machine, except it is hauled by a steel rope wound on a power driven drum. In the upright shear frames are located powerful hydraulic jacks, which crack and shatter the coal, after which a ram knocks it down onto a conveyor to be carried back to the coal car.

These machines, while very efficient, require mining conditions to be made suitable for their performance. Particular attention must be directed to the haulage system, keeping the machines supplied with cars and systematizing the work, reducing delay as much as possible.



Jeffrey Cable Reel Gathering Locomotive



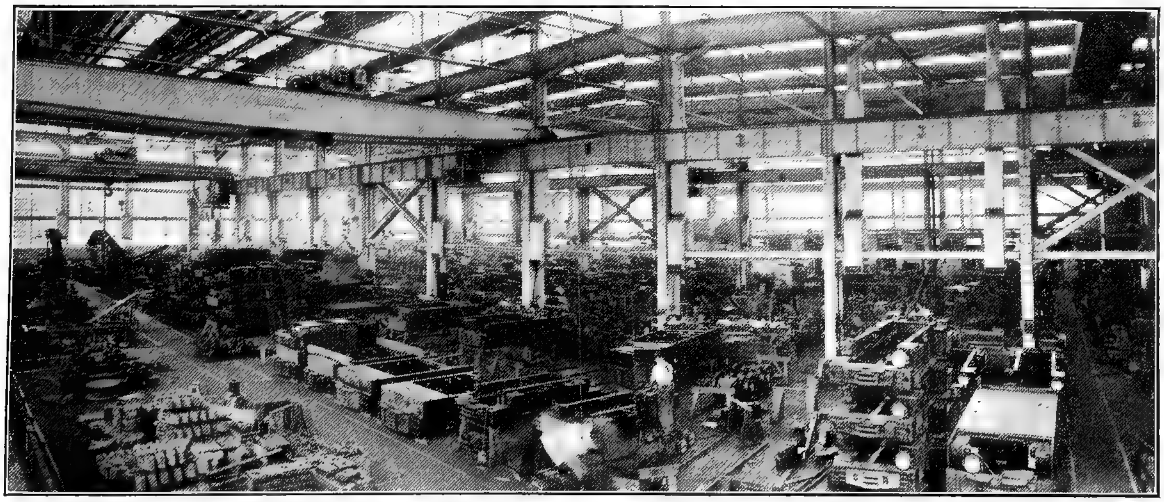
Storage Battery Gathering Locomotive

The early Jeffrey locomotives were of the single motor type and a success from the very start, for as a general proposition each locomotive replaced a number of mules. Since that time the development of electrical equipment for mine locomotives has been very rapid and may be said to have become universal.

Mine locomotives are two types, haulage and gathering. The haulage locomotive varies in weight from six to thirty tons, the motor equipment consisting of a motor hung on each axle with single reduction spur gear drive. On smaller locomotives, the motor capacity is ten horse power per ton at a speed of six miles per hour, and the larger sizes, twelve to fifteen horse power per ton at seven and one-half to eight miles per hour.

The gathering locomotives are divided into three classes. The cable reel type consists of a locomotive equipped with a cable reel, upon which is wound an insulated electric conductor, which permits the locomotive to run into places where no trolley wire is provided, and winds up the cable in even layers on the reel as the locomotive returns to the trolley wire.

The crab gathering locomotive is practically a duplicate of the cable reel locomotive except it is equipped with a motor-driven hoist independent of the electrical



Showing Assembly of Jeffrey Locomotives

equipment of the locomotive. The crab locomotive does not enter the working places but stays in the entry. The trip rider pulls a 3/8 in. steel rope intc the places and hitches it onto the car to be hauled out to the entry where the locomotive is located.

The battery locomotive consists of a steel chassis upon which is mounted a box containing the battery cells. The motor equipment of the battery locomotive consists of either motors designed for the low voltage of the battery, usually 80 volts, or of standard 250 volt trolley motors arranged to run from the trolley when the power is available, and from the battery in places where no trolley is provided.

The Jeffrey Manufacturing Company's plant at the present time covers fifty-six acres and employs 3,000 to 3,500 men. The products consist of coal cutting machines, electric locomotives, elevating and conveying machinery, coal crushers, pulverizers, loaders for coal, sand, gravel and stone, material handling machinery and labor saving equipment of all kinds.

CHAPTER XI

THE DEVELOPMENT OF THE HYDRAULIC TURBINE IN THE UNITED STATES

THE I. P. MORRIS DEPARTMENT OF THE WILLIAM CRAMP & SONS SHIP & ENGINE BUILDING COMPANY

IN the production of electricity on a large scale in the United States, the development of water power has been one of the most important factors, and, conversely, the facility of energy transmission by electricity has been a great stimulant to the utilisation of water powers both large and small all over the world. About the end of the last century, when the building of large water power stations was first being undertaken for the purpose of producing electricity, a new branch of engineering had to be developed in this country—that relating to the special machinery required for converting hydraulic into mechanical power. Indeed, the development of electrical power created the demand for an entirely new type of water power machinery in the world at large.

In tracing the development of hydraulic machinery in the United States, attention may be focused on the work of one company, the I. P. Morris Company, later becoming a department of The William Cramp & Sons Ship & Engine Building Co., of Philadelphia. The work of this concern has not only been typical of the development of the turbine in all its stages, but has included within its scope the bulk of the notable power installations on this continent.

There was no company in a better position to take up this field of work than the I. P. Morris Company in Philadelphia. This company, which was established in 1828, and which in 1891 had been combined with The William Cramp & Sons Ship & Engine Building Company, the latter company having been founded in 1830, had a long record of achievement behind it even at that time. The I. P. Morris Company had specialized in machinery of the largest capacities and the highest class of workmanship. It had built large steam pumping engines and had already constructed a number of important hydraulic turbine installations. Among the early installations of water wheels which are of historical interest may be mentioned the seven turbines for the Fairmount Water Works, of the City of Philadelphia, built in 1851. These were furnished by the I. P. Morris Company from the designs of Emile C. Geyelin. These turbines operated continuously for sixty years, being shut down only on account of the abandonment of the Fairmount Water Works in 1911.

The construction of Station No. 1 of the Niagara Falls Power Co. in 1895 comprised turbines built by the Morris Company from the designs of Faesch and Piccard, of Switzerland. These turbines were of 5,000 horsepower capacity each, by far the largest ever attempted in the world up to that time. The second plant of the Niagara Falls Power Company was equipped with turbines built by the Morris Company from designs of Escher-Wyss & Company, of Switzerland.

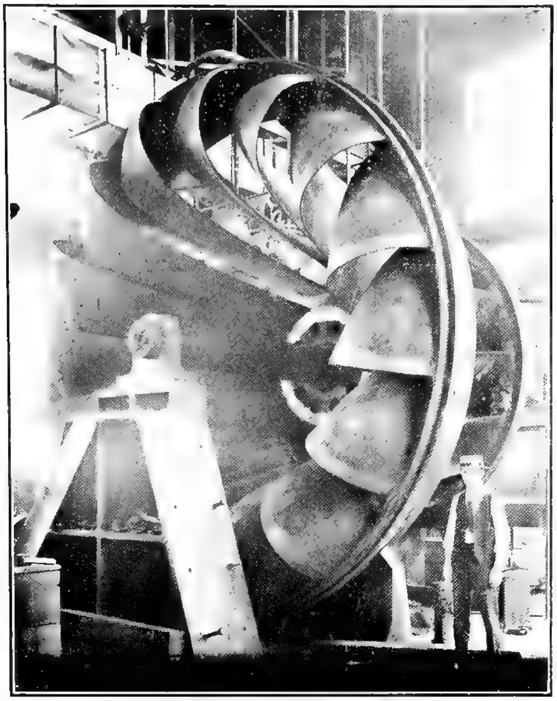


Fig. 1.—10,800 H.P. Turbine Runner, Montreal Light Heat & Power Co., for Cedars Rapids Plant

Recognizing the need for the manufacture of machinery suitable for large hydroelectric stations in this country, the Morris Company undertook the development of this branch of engineering, and began the construction of large turbine installations from its own designs. As a part of the pioneer work carried out by the company in this field may be mentioned the turbines for the Niagara Falls Hydraulic Power & Manufacturing Company, which were installed in 1901. These turbines were of 2,300 and 2,900 horsepower capacity per unit. Two other notable developments were carried out at about the same time, namely, the 2,000 horsepower turbines of the Fourneyron type for the Utica Gas & Electric Company, operating under a head of 266 feet, and the 6,000 horsepower turbines for the Shawinigan Water & Power Company, Canada. Both of these installations took place between 1901 and 1905, and the turbines were built from the Morris Company's own designs. All of these units are still in operation today, although the 6,000 horsepower turbines at Shawinigan have been altered to give 9,000 horsepower capacity.

The success of these installations led to the building of a notable turbine of 10,500 horsepower capacity for the Shawinigan Water & Power Company in 1904, an installation which was followed by two additional similar units in 1906 and 1909. These turbines, which were installed at Shawinigan Falls, in the Province of Quebec, Canada, were remarkably successful, and developed an efficiency of 87 per cent.

Other installations of historical importance in the development of American water power were the following, all built by the same company: The 3,550 h.p. turbines for the Huronian Company at Turbine, Ont; the 8,000 h.p. turbines for the West Kootenay Power & Light Company, in British Columbia; the 13,000 h.p. turbines for the Toronto Power Company's plant at Niagara Falls, and the 10,000 h.p. turbines for the Niagara Falls Hydraulic Power & Manufacturing Company's Station No. 3, at Niagara Falls. These latter turbines developed approximately 91 per cent. efficiency, and thirteen

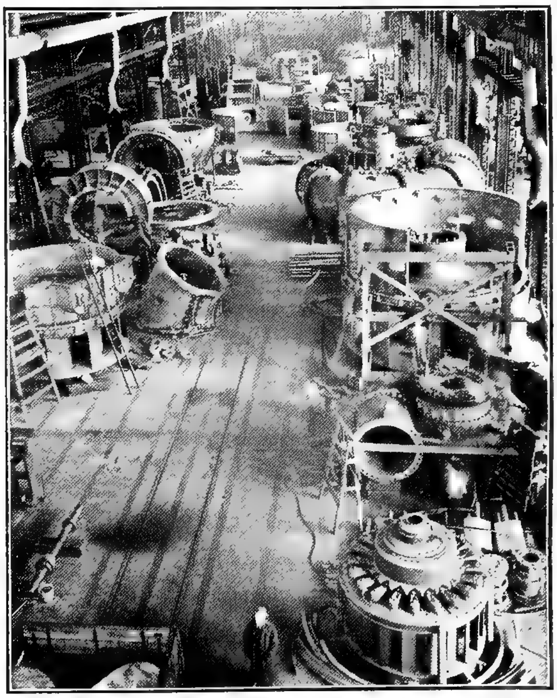


Fig. 2.—Machine Shop No. 2, Devoted to Hydraulic Turbine Work

of these units are in operation at the present time.

A detailed enumeration of all the turbines installed by the Morris Company during the last twenty years would cover a majority of the notable power developments in the United States and Canada. In 1909, for example, this company built

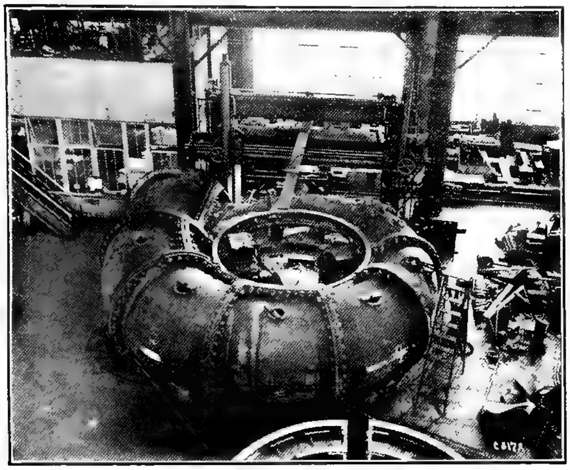


Fig. 3.—55,000 H.P. Turbine Casing, Electric Power Commission of Ontario

the 18,000 horsepower turbines for the Great Western Power Company for operation under a head of 525 feet, and in 1910 built five units of 13,500 horsepower capacity each for the McCall Ferry Power Company's Station on the Susquehanna River, for a head of 53 feet.

In 1910 the Morris Company constructed two turbines of the impulse type, of unusually large size, for the Boulder plant of the Central Colorado Power Company. These were of 10,500 horsepower capacity each, and operated under a head of 1,800 feet.

In 1911, this company built for a new station of the Shawinigan Water & Power Company units of 18,500 horsepower capacity, and constructed two 6,000 horsepower turbines for the Michoacan Power Company, for their Noreiga development in Mexico. These latter turbines were of the reaction type and operated under 670 feet head, so that for many years they were the highest head reaction turbines in the world.

In 1912, the company built units of 22,500 horsepower capacity for the Long Lake Station of the Washington Power Company, in the State of Washington. These were the most powerful turbines in existence at that time.

In 1912, the Morris Company's engineers were influentially instrumental in bringing about the change in turbine types representing the generally accepted practice from the many forms of horizontal multi-runner units which had previously been in vogue to the single runner vertical shaft design which represents the recognized practice of today.

The first important vertical shaft single runner units of modern type were those installed by the Appalachian Power Company in two stations on the New River in the Virginias. Two of these turbines, under careful test by the Power Company's engineers, showed an average efficiency of 93.7 per cent. These turbine units contained most of the features now being used in the most up-to-date installations, including spiral casings molded in the con-

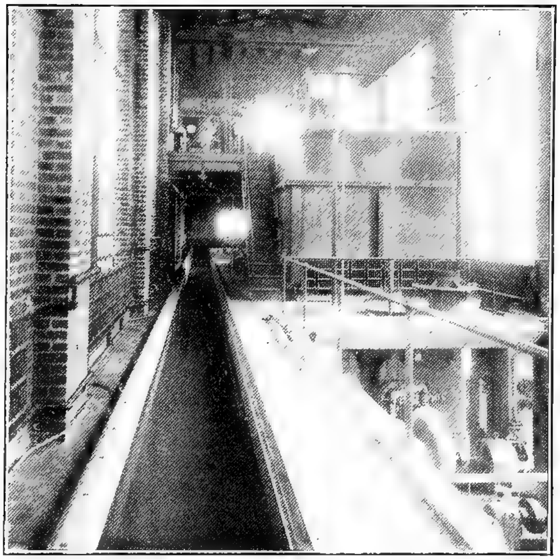


Fig. 4.—Hydraulic Testing Laboratory, Petty's Island, Philadelphia

crete substructure of the power house; speed rings containing cast stay vanes imbedded in the power house substructure; thrust bearings mounted above the generators and operating mechanism, for controlling the wicket gates of the turbine, arranged in a pit above the turbine head cover, the main shaft bearing and the

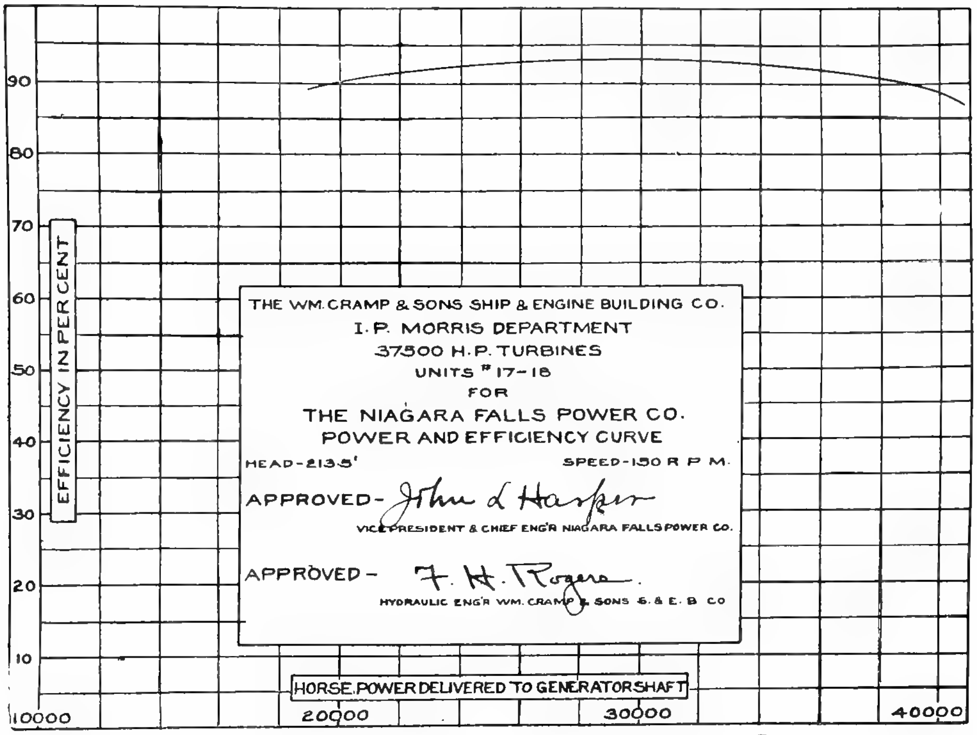


Fig. 6.—Niagara Falls Turbines: Power and Efficiency Curve

operating gear being accessible for inspection and lubrication.

A still larger installation, having generally similar units, then followed, that of the Mississippi River Power Company at Keokuk—for which this company furnished eight turbines of 10,000 horsepower unit capacity, in 1913. This station was one of the largest hydraulic power developments which had ever been carried out up to that time, and on account of the low head—32 feet—the turbines were of unusual dimensions, being the largest in size that had ever been constructed.

In 1914, another installation having units of similar design to those of the Appalachian Power Company, but of larger capacity, was built; that of the Alabama Power Company at Lock 12 on the Coosa River. These turbines, of 17,500 horsepower capacity each, presented another extremely successful development.

Continuing the same line of progress, the Morris Company built in 1914 for the Cedars Rapids Manufacturing & Power Company for their great station on the St. Lawrence River nine units of 10,800 horsepower capacity each, for operation under 30 feet head. These units still remain the largest in point of dimensions that have ever been constructed. Figure 1 shows one of the runners for these turbines. These runners are constructed in four sections, bolted to a cast steel crown and cast steel band.

Another installation of similar design and of smaller dimensions but of larger unit capacity, was that of the Laurentide Company, Ltd., at Grand Mere, Canada, comprising six units of 20,000 horsepower unit capacity. These were the most pow-

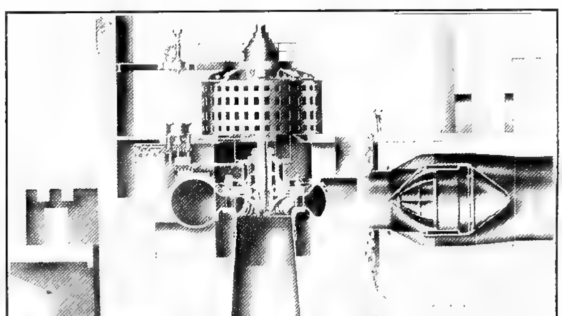


Fig. 5.—37,500 H.P. Hydraulic Turbines for Niagara Falls Power Co.

erful units of this type in the world at that time.

The Morris Company, which has now been entirely merged in the Cramp Shipbuilding Company as one of its leading departments, has exhibited careful attention in maintaining and improving its shop and engineering facilities, as has been shown in the continual improvement of its product. Figure 2 shows a view of the interior of the I. P. Morris Shop No. 2, one of the shops devoted to hydraulic turbine work. Figure 3 shows the machining of a cast steel casing for the most powerful turbines ever constructed—the 55,000 horsepower turbines for the Niagara development of the Hydro-Electric Power Commission of Ontario, which will be referred to later.

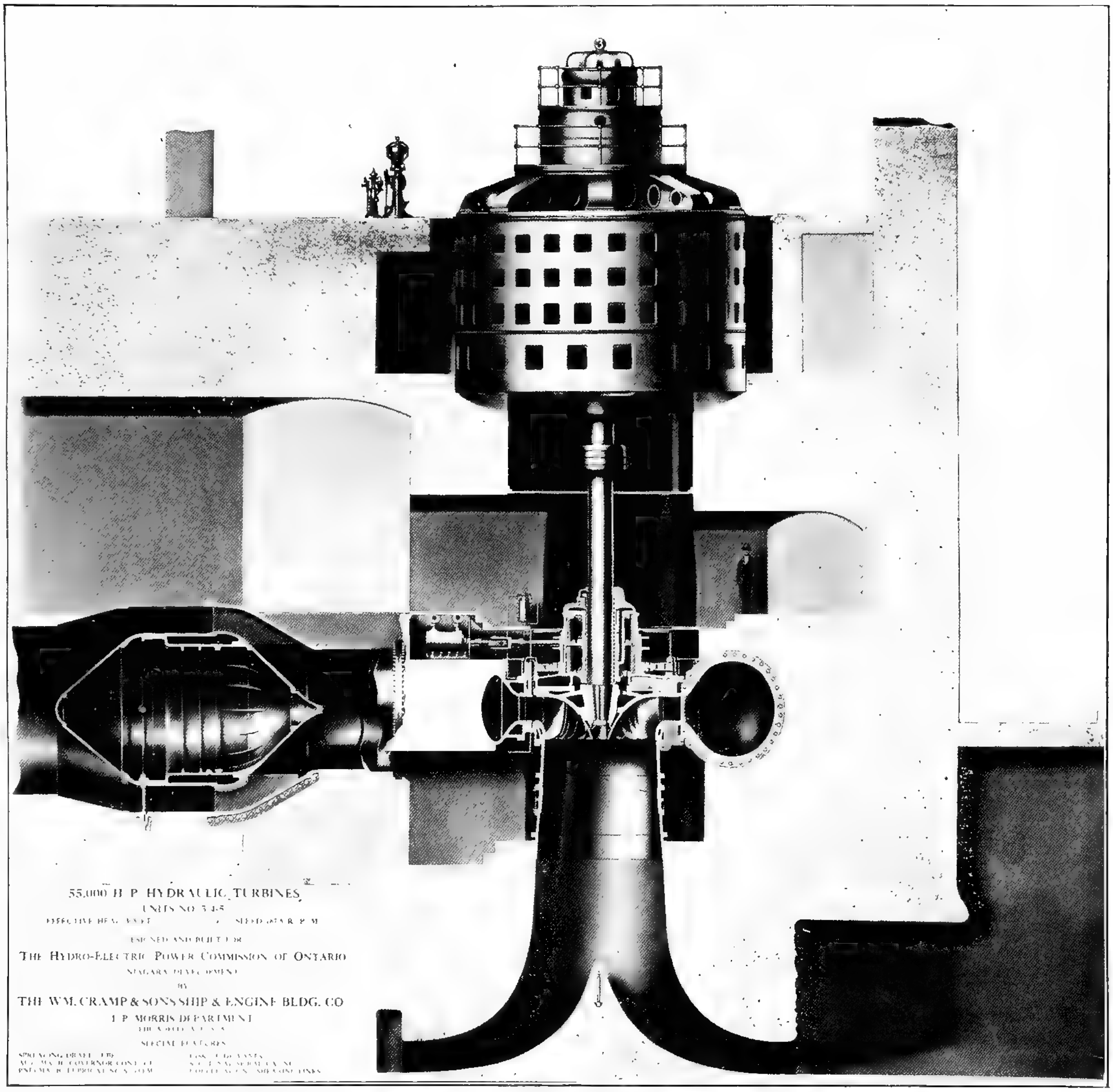


Fig. 7.—55,000 H.P. Hydraulic Turbines Designed and Built for the Hydro-Electric Power Commission of Ontario

In addition to the most modern shop equipment, the Cramp Company has recently constructed a specially designed hydraulic laboratory on Petty's Island in the Delaware River, opposite the shipyard.

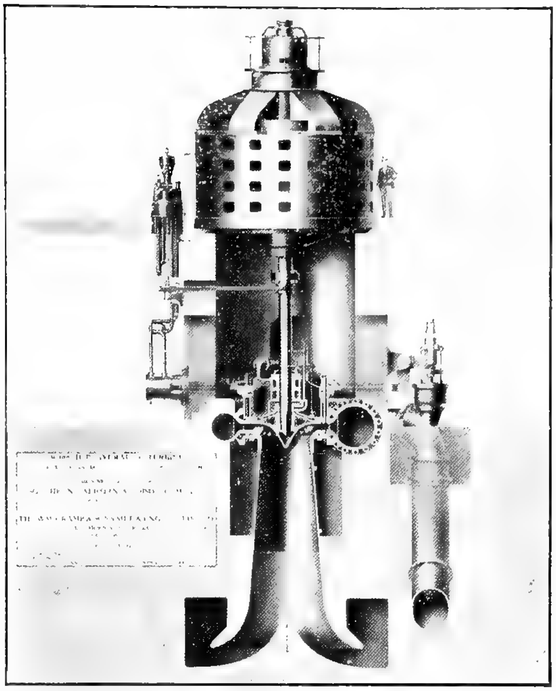


Fig. 8.—30,000 H.P. Hydraulic Turbine for Southern California Edison Co.

A view of the interior of this laboratory is shown in Figure 4. In this laboratory, model turbines, complete with draft tube or other water passages, can be tested; and great care has been expended in installing the most accurate measuring instruments for this work. Among many accomplishments of the laboratory may be mentioned some new forms of high speed turbine runners, which have been thoroughly tested out in this laboratory. Another development is a new "Ejector Turbine" for the utilization of surplus flow during flood conditions.

The same kind of pioneer work which has been accomplished in the past by this company is being carried out at the present time, and it is confidently predicted that the next few years will show that the Cramp Company has lived up to its traditions in leading the way to further important improvements in the construction of hydraulic machinery.

The many installations recently completed and those in course of construction show a number of the new features introduced by the engineers of this company. Figure 5 exhibits the 37,500 horsepower turbines for the Station No. 3 Extension of the Niagara Falls Power Company. Figure 6 shows the curve of efficiencies obtained in an extremely accurate test of these turbines made by the Power Company's engineers. In this test, the new "Gibson" method of measurement of water quantity was used. This curve is believed to show the highest average efficiency from half-gate to full-gate ever secured in a hydraulic turbine. As will be noted from Figure 5 a new form of draft tube, known as the "Moody Spreading" tube, was used in these units and is believed to have materially contributed to the securing of the unusually high part-gate efficiencies obtained. The efficiency at normal gate was 93 per cent.

Still more powerful units of similar design are now nearing completion for the Niagara Development of the Hydro-Electric Power Commission of Ontario. These turbines, a cross section of which is shown in Figure 7, are of 55,000 horsepower capacity and operate at 187½ R.P.M. under a head of 305 feet. Among other features to which attention may be called in these turbines, are the use of a new method of constructing the casing, which is shown in Figure 3; a new design of guide

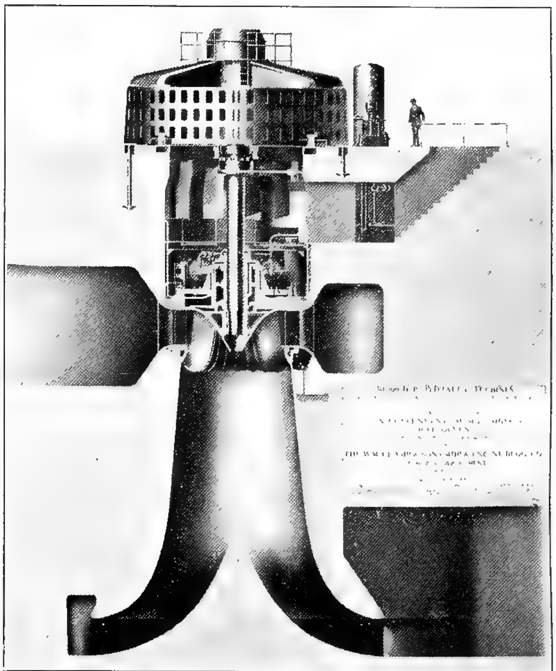


Fig. 9.—30,000 H.P. Hydraulic Turbine for Muscle Shoals Development

vanes, which includes integral disks at the top and bottom of the vane, increasing the strength and reducing leakage; a new method of employing the labyrinth principle for reducing the leakage around the runner; and a new design of operating mechanism. These turbines, in common with the Niagara Falls Power Co.'s units, also include the use of the spreading type of draft tube, and this type of tube has also been applied to a unit of other manufacture installed in this station. Two other useful features which were applied to the Niagara Falls Power Company's plant have been used in this installation, namely a system of automatic valves for throwing on and off the governor, and hand-control of the turbines, by the use of fluid pressure control from a single lever, and also the feature of a pneumatic lubricating system, which greatly facilitates the proper lubrication of the many bearings of the operating gear.

Figures 8 and 9 show two other notable recent developments of quite different characteristics, viz., Figure 8 illustrating the 30,000 horsepower turbine for the Big Creek No. 8 plant of the Southern California Edison Co., which has recently been put in operation under a head of 680 feet; and Figure 9 one of the 30,000 h.p. turbines for the United States Government Plant at Muscle Shoals, which is to operate under a head of 95 feet. The Southern California Edison unit is an excellent example of the reaction turbine applied to an extremely high head, and the Muscle Shoals unit is an example of a large modern development under a moderate head.

CHAPTER XII

THE DEVELOPMENT OF THE ELECTRICAL FUSE MANUFACTURING COMPANIES

THE value and importance of a good fuse is much better appreciated today than it was in the earlier periods of the electrical industry, when this invaluable accessory was literally unknown, or used with so little recognition of its vital function that the earliest Edison lighting circuits, for example, were fused only on one side. Not only did interior circuits suffer, but history records how on one occasion the fuses "blew" on the Wall Street feeder of the New York Edison Company, so that the system "lay down," while the capitalists backing the young enterprise had real heart failure. Less than five years after that, when Frank J. Sprague was demonstrating the merits of electric traction on the Manhattan Elevated lines, the late Jay Gould, one of the principal owners, during the operation of the car was standing near the controller and an open fuse. The fuse blew with a blinding flash, followed by Mr. Gould's frantic efforts to jump off the car,—and the subsequent proceedings in electric traction interested him no more—never again!

CHICAGO FUSE MANUFACTURING COMPANY

The record of the Chicago Fuse Manufacturing Company goes back to even such remote and early days as those referred to above, for it was not far short of thirty-five years ago that the concern began in a very modest way making electrical fuses in a little shop of a side street. Everything was really quite insignificant except the underlying controlling ideas. Today the leaders in the enterprise naturally know more about fuses than they knew then, but the principles recognized at that time and put in force remain the same now, when the company occupies an entire plant of its own, covering almost a whole city square in the center of the most favorably located manufacturing district in modern Chicago.

It is needless today to emphasize the importance of the function of the fuse in the vital duty placed upon the device in practically every department of electrical application, and particularly in the use of current for light and power. The failure of a fuse to quench an arc promptly, following a short circuit, saving life and property, and avoiding shut down, is a risk that no one has the right to assume when devices amply and infallibly protective are on the market. Essentially in the nature of a thermal protective device, an enclosed fuse depends for its operation upon the conversion of a certain number of watts into heat units, which when imposed upon the metal of the fusible element, raises its temperature to the melting point, and causes the circuit controlled to open. As the severed ends of the fuse element part from each other, an arc is drawn between them, which instantly converts the molten metal of the link into vapor. The ease with which the initial "arc" is killed "a-borning," choked at its birth, and the vapor, itself conducting, can be condensed, minimized, neutralized and rendered non-conducting and non-dangerous is what

further determines the character and success of the device. Obviously many conditions enter into the process of restoring safety, and all these have for years involved study of physical phenomena and electrical vagaries which from the very nature of the subject are most difficult to analyze in advance. Probably few electrical circuit conditions have received more intense investigation than those dealing with the relation of fuses to the circuits and currents to be controlled, and the nature of the fuse itself—sensitiveness, length, diameter, heat conductivity, the fuse element proper, location, temperature, original and renewable costs, handiness, acceptability to the underwriter tribe—and other factors, all interacting and entering into the production of the perfect satisfactory appliance. Beyond the simple production and use of an adequate renewable fuse lies the debatable ground of uncertainty, however, as to where to use it, for as the Chicago Fuse Manufacturing Company has pointed out, thousands of concerns even now are using renewable fuses where the non-renewable type should and could be used, because on lines subject to very few blow-outs; just as on other lines the liability to short circuit calls for the renewable type. Not only has the Chicago Fuse Manufacturing Company developed both types of the highest grade, but its service department has been built up as a means of eliminating such unprofitable and objectionable operating conditions and has placed at the command of the consumer the best advice of the expert fuse engineer.

The "Union" enclosed fuses of the non-renewable type made by the Chicago Fuse Manufacturing Company were approved as far back as January in 1907. The "Union" renewable enjoys the same approval to the fullest degree. The fundamental feature of its fuse is that it literally decapitates itself instantaneously. The "blow-out" is complete. The gap left in the very center of the fusible link is so clean-cut and wide that arcing as it is ordinarily understood is absolutely impossible. And by the self-extinction of the arc by suicide there is also a minimized generation of gases such as in common fuses leave a deposit on the nearest nut and screw and even "runs together" the fused metal parts. Nor when the link lets go is there any flash or violent explosion. It is sane, safe and silent.

In the "Union ferrule" type of renewable fuse, the heavy brass parts are securely attached to the outside of the tubing. When the cap is unscrewed, the washer supporting the end of the renewal link is exposed, and if it does not drop out of its own accord, it is very easily removed; and no tools are needed. The solidity of the metal parts ensures their coolness in service use. The links are supplied with one end bent to save time and render the insertion exactly accurate. Ordinarily it requires much time, patience and deftness to bend a straight link just about the way it ought to be for renewal purposes.

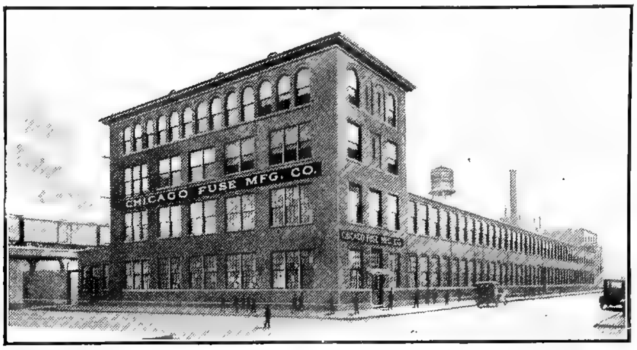
In the "Union" knife blade type of renewable fuse, the metal ferrules are securely riveted and screwed onto the outside of the tubing. This connection is not disturbed in renewing, and all changes occur between long-wearing metal surfaces. The flexibility of the knife blade fastenings allows the blades to adjust themselves readily in the mounting clips and so make good contact.

The "safety valves" at each end of the larger sizes, where needed, permit gases, if generated, to escape quickly when the fuse blows. These additional protective safeguards consist of four small vents, or holes, in the end metal washers, while the leather washers are without them. When a link "blows," the pressure lifts the leather washers enough to let out whatever gases may be generated, but yet not sufficiently to permit any flame or arc to escape. This simple plan is in itself enough to save thousands of fuses from being so exploded to atoms that the word "renewable" quite ceases to have any meaning. No tools except an ordinary screwdriver, or monkey wrench, are needed for making renewals with the "Union" knife blade renewables, or, for that matter, with the non-renewables. This not only means saving good fuses from the scrap heap but carries with it a notable reduction in the cost of handling in these days of high wages. It is a truism that the fate of many "renewable" fuses is to be discarded

before their time because they are difficult to renew and because the unskilled or wasteful "electrician" has disdained to bother with them. Moreover a "Union" renewable fuse will take punishment like a Dempsey and come back after an incredible number of the "knockouts" due to "blows."

It follows from the remarkable development of the enclosed fuse industry of the company as exemplified in the "Union" renewable and non-renewable types just discussed all too briefly above, that it has followed through into other lines of manufacture, and not merely of fuses, as in its "Automobile" types, which, of course, involve other special conditions. The whole field is to be regarded as calling for its productions in electrical protective materials and devices and conduit fittings, besides which it makes correlated lines of special parts for automobiles and stampings of all kinds. When it is remembered that interior wiring began with exposed circuits run on knobs, or with wires buried in the plaster, it is extraordinary how the art of enclosed wires has grown up not only carrying with it the idea and practice of enclosed fuses, but has necessitated the working out of the new modern accessories in "enclosed" switch and outlet boxes of the most varied nature and design. The whole utilization of electricity, industrially and in the household, is based primarily on the enclosed wiring and the enclosed fuse, with their auxiliary apparatus in the boxes that means so much as regards safety and reliability of service. Here, too, lies no small part of the fame and reputation that the Chicago Fuse Manufacturing Company has won in building up its trade throughout over a quarter of a century in a period of unparalleled advance and activity, holding its own pioneer lead, and contributing in large measure to the common gain and general good.

The Chicago Fuse Manufacturing Company is located at Laflin and Fifteenth Streets, Chicago, in a new home, a modern daylight structure built according to the latest ideas and principles of factory design and embodying in its construction all the up-to-date practices that lead to economy in operation and perfection in product. The machinery equipment is efficient and ingenious, and illustrates the skill with which new processes can be applied to new products in new arts. Chicago is a most admirable center for the manufacture and distribution of goods consumed in all parts of the country. The employees number over three hundred of various nationalities. The officers are: President, A. D. Dana; vice-president and general manager, W. W. Merrill; and secretary-treasurer, G. C. Reid. A capital of $300,000 is used, and the territory covered by salesmen, forceful advertising and representative agencies embraces not only the United States and Canada but many foreign countries.

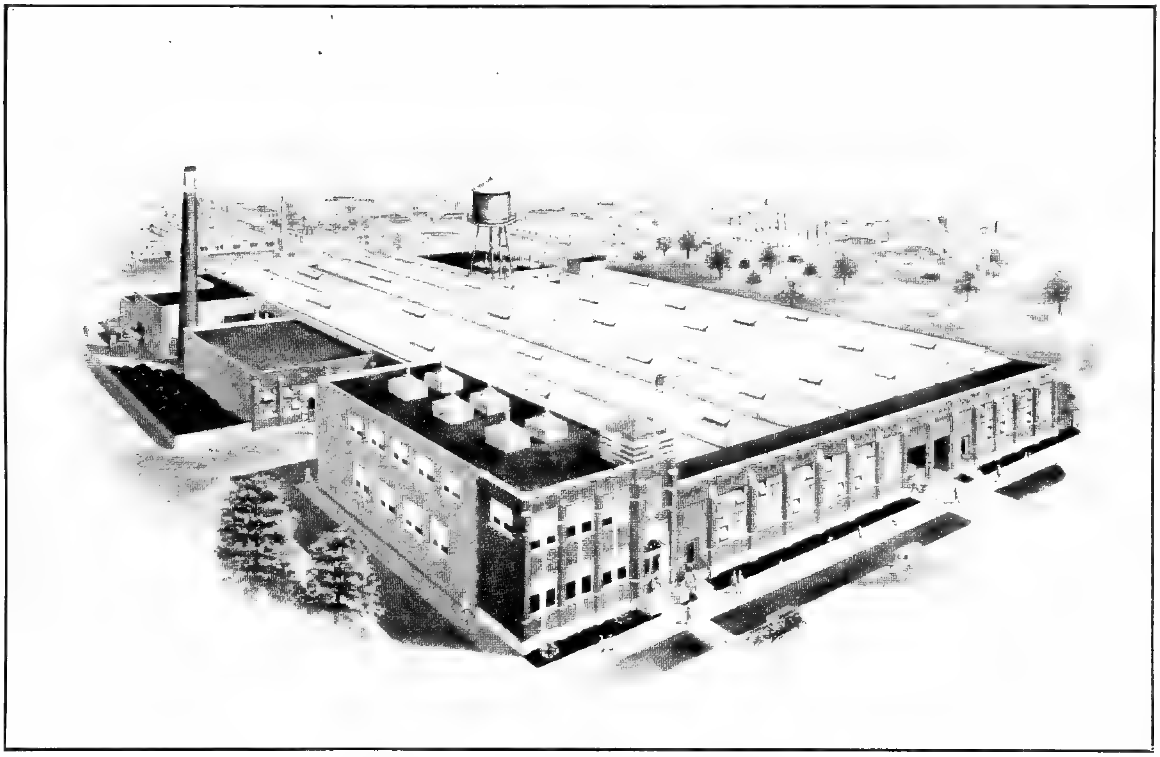


Factory of the Chicago Fuse Manufacturing Company

ECONOMY FUSE & MANUFACTURING COMPANY

The story of the growth of the Economy Fuse & Manufacturing Company is a record of the achievement of young men with imagination and unwavering courage; of the execution of their convictions, and of their belief that an article which best and most economically served the public need, however much opposed, would, in spite of overwhelming opposition, ultimately enjoy a great demand, and go into general use in illimitable quantities. It is also a record of remarkable progress in the application of sound ideals to an intensive utilization of men, methods, machinery, materials, money and commonsense,—associated with an unprecedented program of patent battles, national advertising and advanced sales methods.

The Economy Fuse & Manufacturing Company, as pioneers in the manufacture and marketing of cartridge enclosed fuses of the renewable type, has accumulated vast resources of information, pertaining to the design, construction, and operation of thermal fuses of all descriptions, and holds the key to the treasure chest of priceless experience, gathered in attacking and analyzing the problems of design, and



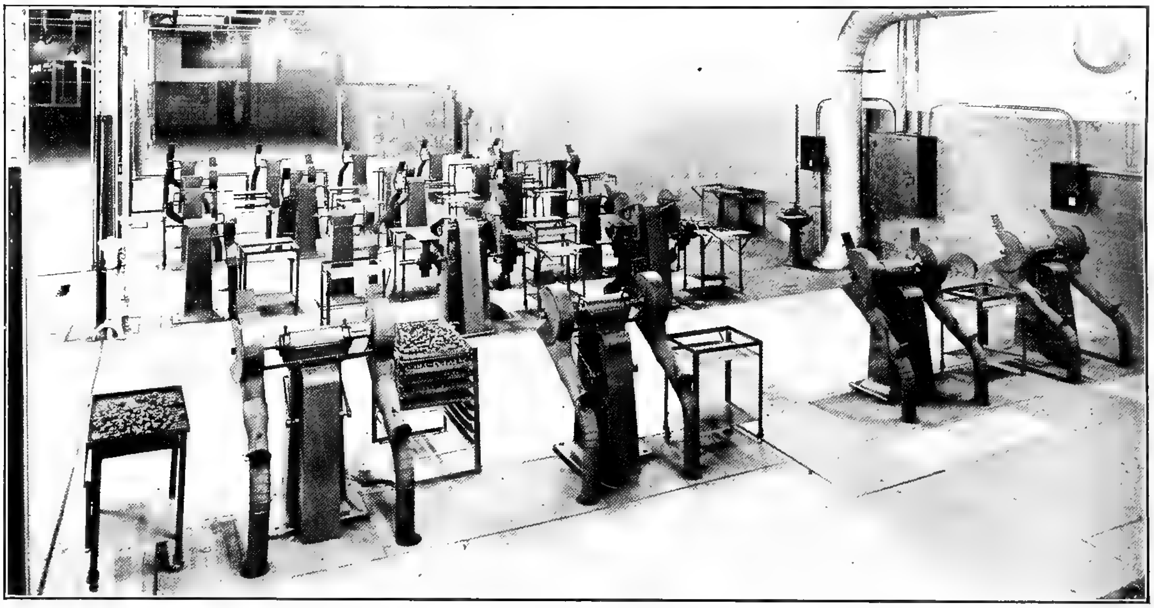
Plant of Economy Fuse & Manufacturing Company, Chicago, Ill.
This factory, as to exterior, interior, and all its installations, is considered a model of its kind. Attention is directed to the illustrations of the interior showing the trench system used which provides all possible requirements for service for rows of machinery, such as electric current, gas, water, oil, cutting compound, etc.

performance in commercial use. Its proved-out-in-practice designs have become a guide and a stimulation to still greater efforts toward a further development in the art of thermal fuse design, with incalculable benefit to the art and the public in minimizing fire and accident hazard.

The Economy Fuse & Manufacturing Company was organized and incorporated in 1911, and was located in very small quarters at Pittsburgh, Pa. Its business was so small that it was not at first able to support even the "one man" organization. But after a few months, in the Spring of 1912, the original customers came back with many repeat orders of greater size, and contrary to all predictions it had been demonstrated that a reliable fuse of the renewable type not only could be made, but could find an increasing field of use.

In the Spring of 1912, a request was made by the Underwriters' Laboratories to the Company, to submit its "Economy" Renewable Fuses to them for examination and test. The contents of the "two by four" plant were loaded into a car and shipped to Chicago, where electrical test facilities were readily obtainable, and after a suitable location was found, the business was re-established in modest quarters. Then the product was submitted to the Underwriters' Laboratories in May, 1912, for examination and test, with a view to obtaining "approval," or the marking of the fuses as "Standard" and to secure the listing of the trade name of "Economy Fuses" in the list of "Inspected Electrical Appliances."

The tests were completed and the report issued about July, 1912, and while they showed a thoroughly satisfactory performance, the Underwriters' Laboratories concluded that the rules of the "National Electrical Code" did not permit the marking of renewable fuses as "Standard," and referred the question to the Switch and Cut-Out Committee of the Electrical Committee of the National Fire Protection Association for their consideration and advice. The findings of this Committee were not satisfactory to the Economy Company, as no definite action had been taken, and thus for some years the question was involved in many spirited protests and discussions in the various Committees and Associations.



Polishing Department of the Economy Fuse Manufacturing Company

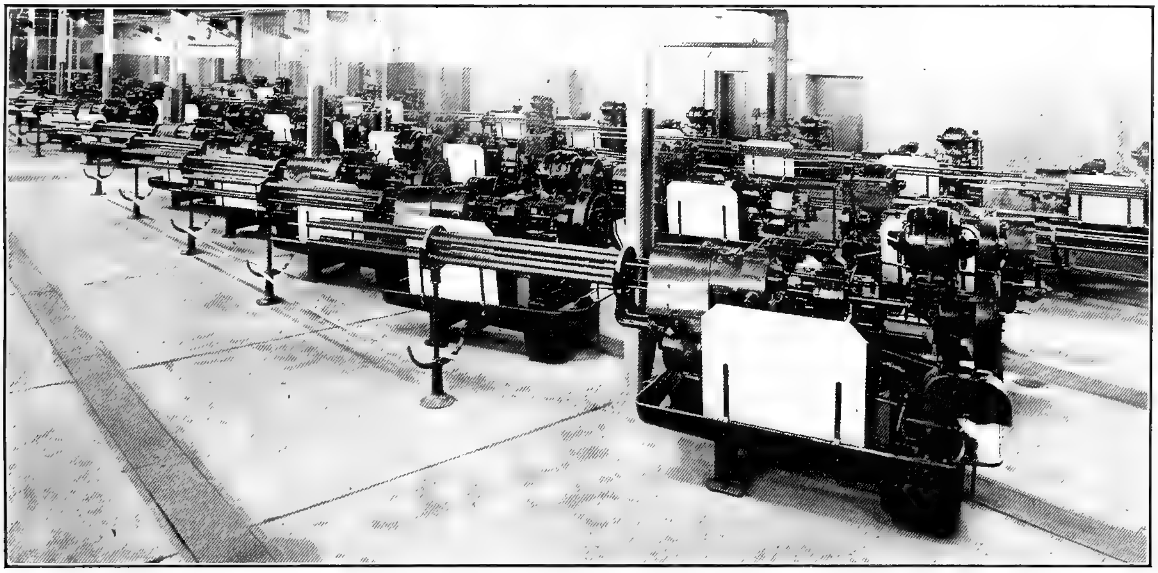
As pioneers in the Renewable Fuse field, the problems encountered by the Company were most serious. The united opposition of manufacturers of the then standard

non-renewable fuse, together with the unfavorable attitude of the National Fire Protection Association, and its various committees, forced the Economy Fuse & Manufacturing Company, in self-defense, for its "right to live," to resort to public hearings before the interested committees. Still no relief or satisfaction was obtained, and, at last, a restraining order of the courts prevented the Electrical Committee from doing any act which would be detrimental to the Economy Fuse & Manufacturing Company. Finally, at the invitation of the Underwriters' Laboratories, the Company was induced to submit the question of the relative fire hazard to the U. S. Bureau of Standards for arbitration, as a national unbiassed arbitrator.

The Bureau of Standards, after months of investigation and hearings, reported its findings, and recommended an extension of use in order to determine definitely the relative hazards of Economy Renewable Fuses as compared with other non-renewable fuses listed as "Standard" by the Underwriters' Laboratories. Actually a two-hundred page book was issued by the Bureau of Standards on the subject. (Technologic Papers, Bureau of Standards, No. 74, December 1, 1916.) Meanwhile, the Economy Company had secured written permission for the use of its product from various municipal and Underwriters' Inspection Departments, the future was bright, sales increased by leaps and bounds, and the plant was greatly enlarged several times. But, at the same time, the company was now confronted with a new form of opposition, when several patent infringement suits were entered against it by manufacturers of non-renewable fuses.

In the first decision of the Courts, an injunction was issued restraining the further manufacture and sale of Economy Renewable Fuses, as then manufactured, and it was this event which proved to be a forceful illustration that "Necessity is the Mother of Invention." Soon through sheer necessity a new form of fusible link was discovered, which proved up wonderfully in performance, and ranks as a high order of invention. A basic patent of fundamental nature was issued in due time.

This invention, popularly and universally known as the "Drop-Out" link, reduced remarkably the quantity of fusible metal volatilized on "blowing," because the greater part of the metal was not fused. A large section "dropped-out" of the circuit in metallic form, establishing a plurality of arcs in series, thus reducing the internal operating pressure to such a



Screw Machine Department of the Economy Fuse Manufacturing Company

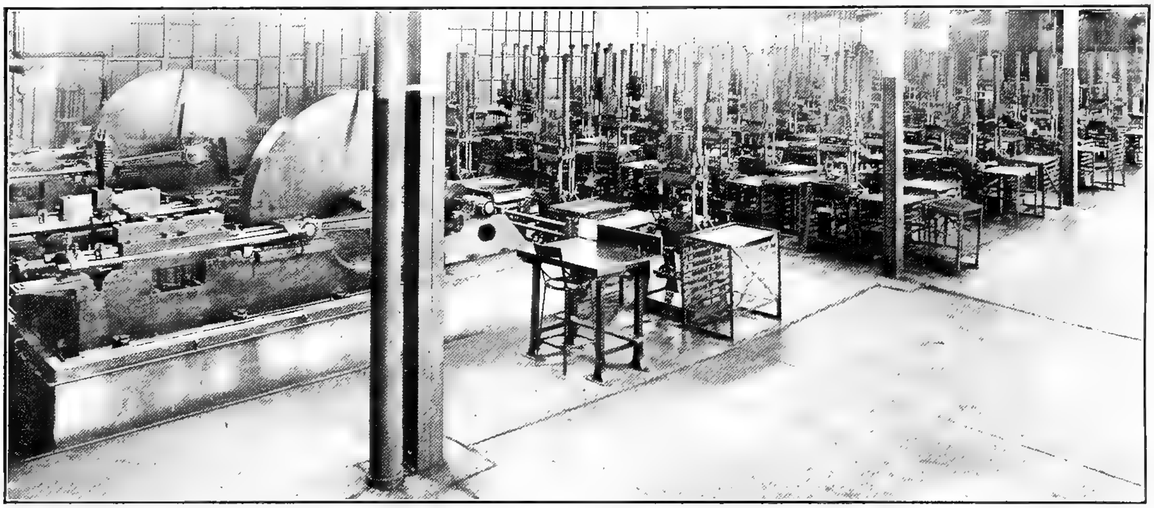
degree that the old conventional so-called "arc quenching" and cooling filling material was no longer necessary; and hence the filling material was omitted. The fuse with the "Drop-Out" link was then generally referred to as the air-space type in comparison with some ten standard non-renewable constructions in which filling material was employed.

Once more the demand for the "Drop-Out" type of fuses intensified until a six-story building was required to house the business. The pioneer Economy Renewable Fuse was the only renewable fuse in real popular demand, and as a result, several manufacturers, in the early part of 1918, solicited and were granted manufacturing licenses under the "Drop-Out" link patents. Today no fewer than eight producers are manufacturing or selling renewable fuses under the license and the methods of the "Drop-Out" system.

It was this technical and commercial victory that proved the truth of what Mr. W. H. Merrill of the Underwriters' Laboratories said at the Bureau of Standards: "Nothing that is wrong eventually prevails in America." Immediately, the Fuse Section of the Associated Manufacturers of Electrical Supplies prepared a "Standard for Renewable Enclosed Fuses" which was adopted by the Underwriters' Laboratories and published in July, 1919, under which Economy Renewable Fuses were "Approved" in all capacities under the Label Service Plan of Inspection in the Fall of 1919. Another notable chapter of electrical progress had been written.

The Economy Fuse & Manufacturing Company now occupies a modern plant of 70,000 square feet, and manufactures in addition to Economy Renewable plug and cartridge fuses, Arkless mechanical indicating non-renewable fuses, and a plug fuse formed of moulded insulation with no metal exposed except the screw shell, and with a window permitting clear view of the condition (blown or not blown) of the "Drop-Out" link. This fuse is called "Clearsite" and is marketed under a novel selling plan, which includes retail packages containing four fuses at a price of twenty-five cents. The employees in the plant of the Company average about six hundred; the office employees and department heads average about fifty; and the Company maintains twenty sales offices with an average of one hundred twenty-five salesmen, and also has an affiliated company for the production and sale of Economy Renewable Fuses in Canada, at Montreal.

The business and the plant of the Economy Fuse & Manufacturing Company are a monument to the ability, vision, and determination of the President of the Company, Mr. A. L. Eustice, whose unceasing efforts and skill in turning defeat into victory have built up a huge annual business from nothing in the short space of only ten years.



Hydraulic Press Department, Economy Fuse Manufacturing Company

A. F. DAUM

The electrical field is so young that many men who are even less than middle aged may be designated as pioneers in its various lines of development. A name familiar to the readers of electrical journals during the past ten years and particularly to the purchasers of fuses for electrical light and power, is that of Mr. A. F. Daum of Pittsburgh, Pa. Mr. Daum makes a distinctive claim of having manufactured the original refillable fuse—an appliance which has worked steadily to the convenience and economy of all electric light and power users.

Mr. Daum began the manufacture of his product in 1908, located at 1158 Hodgkiss Street, N. S., Pittsburgh, Pa. He is the sole owner of the plant, and continues at the same address. In comparison with some of the great manufacturing establishments in the electrical field, the plant is a modest enterprise, yet it has progressed under his careful direction and ingenuity until it has attained a reputation for the manufacturing of fuses which are simple and inexpensive and at the same time fool-proof. The product has been greatly improved and simplified since the original fuse was manufactured and now includes all of the essentials of a successful reliable fuse. Simplicity in manufacture, ease in refilling and inspection, few parts, sufficient weight not to be easily lost, and an inexpensive maintenance are a few of the features that recommend the Daum fuse.

The refilling of the fuses is a simple operation, as one merely unscrews the caps, inserts the strips without tools or any accessories, the caps are then replaced and the fuse is again ready for service. Renewals are so made as to carry a 25 percent over-load at all times, and a 50 per cent over-load from one to five minutes, depending on their sizes. In the type B of Daum fuses, commercial fuse wire is used. In reloading these 250 volt fuses up to 30 amperes, the wire will carry 100 per cent more than its rating. Mr. Daum manufactures these fuses in every description, including the refillable fuse plug, and is prepared to make from a sample drawing any fuse of the refillable type, thus being able to solve fuse problems for any and all cases.

The reputation for simplicity and economy which has attached to the Daum fuse during its ten or twelve years of existence, has earned for it a distinct place in the electrical field. Recent radical improvements which have been introduced by Mr. Daum have placed his product on an even firmer foundation, and customers are guaranteed satisfaction or the fuses are returnable without expense to them should such a contingency occur.

CHAPTER XIII

DEVELOPMENT OF THE ELECTRIC FURNACE

A MODERN MASTER INDUSTRY

DETROIT ELECTRIC FURNACE COMPANY

THE electrical transmission of speech and signals—of intelligence, electric light and power, electric locomotion and traction—have long been known as master industries. To these more recently have been added many newer arts in the fields of electro-chemistry and electro-metallurgy, and now the world begins to hear of yet later achievements as in electric water-proofing. The process, indeed, never ceases whereby old industries are revolutionized and newer ones added to the resources of civilization. "Behold, I make all things new," is an inspired phrase which might well be appropriated for protean electricity.

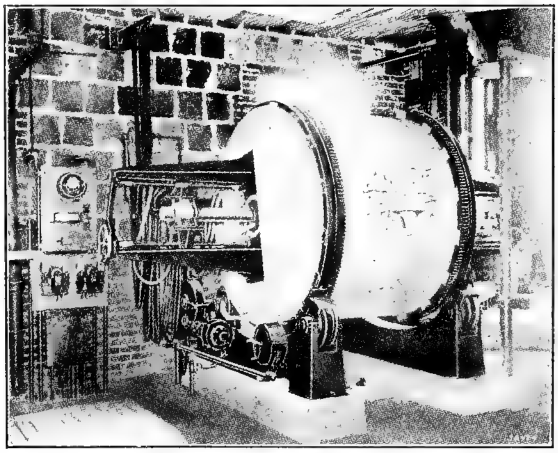
And yet, even when by mere swift sequence of novelty one becomes somewhat hardened against yielding to surprise at further innovations, it is startling to note the issuance early in 1920 of a "reading list" of references to articles and papers on the electric furnace as applied to metallurgy, by the American Electro-chemical Society. It ran a length of not less than one hundred pages, and yet these did not assume to go further back than 1900, at which time, as a landmark, it is postulated that the electric furnace was becoming established in the iron and steel industry. The newness of the whole thing may be inferred from the following remark of the late Prof. Joseph W. Richards, of Lehigh University, in an historical review in the *Journal A. I. E. E.*, of December, 1920, when he said:—"About 1877, Siemens got the idea that it would be possible to melt steel commercially by the use of the electric arc. He spent a great deal of money and exercised a good deal of ingenuity in trying to melt steel in a crucible by means of the electric current. He tried this in two ways: First of all to melt the steel by radiation from an arc, and second by making the steel one pole of an arc."

The interesting review noted above, by Dr. Richards, closes with a suggestive note on electric furnaces for non-ferrous metals, which may well be quoted here. He says:—"The metals particularly in mind are brass and bronze—copper and aluminum being secondary in consideration. Brass contains zinc, a metal fairly volatile at a bright red heat. The considerable loss of zinc by volatilization must be guarded against. If brass is made in an electric furnace of the proper construction, volatilization and oxidation of zinc may be reduced to a very small amount (1 to 3 per cent). The radiation furnace, which radiates heat directly on the metal, is very inefficient for this sort of work, boiling out the volatile materials very rapidly from the part of the surface which becomes overheated. This disadvantage of the arc radiation furnace has been overcome by active circulation of the bath, thus keeping the metal at a uniform

temperature. This principle is being utilized very efficiently in brass furnaces, which work by arc radiation and yet lose very little zinc by volatilization." To which may very appropriately be added the remark made before the Society in April, 1920, that: "Electric brass melting can no longer properly be called 'the coming thing.' It has arrived in a most convincing fashion, as is evidenced by its rapid adoption by the larger and more progressive rolling mills, foundries and manufacturing establishments which use brass in large quantities."

At this point the story necessarily converges on the Detroit Electric Furnace Company, which has chosen the melting of non-ferrous metals as its specific field of operation, and whose first electric rocking furnace was installed for commercial use as recently as July, 1918. Only three years later, or by July, 1921, to be exact, it had already installed no fewer than 80 furnaces in daily operation on all of the various non-ferrous alloys as well as gray iron and steel. This interesting type of furnace is illustrated herewith. It has been introduced by the makers in various sizes, from one-eighth ton to one and one-half tons, equipped with everything necessary to complete installation, i.e., furnace transformer, meters, control switches, motor for rocking, electrically operated oil switch with control relays and high tension panel, as well as electrodes and refractory linings. The company also furnishes the services of an expert installation engineer, who supervises the equipment and initial operation of the furnace at the purchaser's plant.

A few details of a technical nature are in order. In operation, the furnace is rocked during the melting period, the rocking being accomplished by a very simple electrical device, which automatically reverses the direction of rotation of the driving motor. The extent of such rocking is controlled by the movement of a single lever, so that before the end of the rocking period, the entire inner surface of the furnace is washed by the molten metal, with the exception of that section occupied by the charging door. As a highly beneficial result of this constant agitation of the molten metal, any local superheating of the charge and consequent loss by volatilization is prevented. Moreover, by such continual stirring a thorough mixing and blending of the materials occurs, and an absolutely homogeneous metal, when poured, is the result. In addition, extremely long life of linings is assured by such incessant washing, the lining is very slightly hotter than the metal charge itself and is always greatly below the safe upper temperature limits of the refractory used. In many instances,

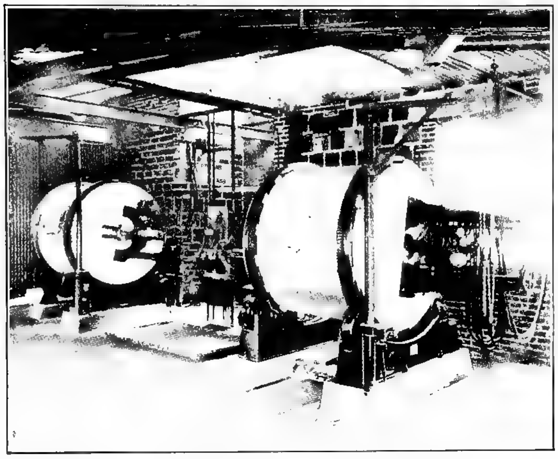


The Latest Type Detroit Furnace

Detroit linings have operated over 1,200 heats before replacement became due; yet, two thousand pound charges of yellow brass have repeatedly been melted in from thirty-five to forty minutes. In fact, speed of production is effected by the charge being heated by direct radiation from the arc as well as by conduction from the lining. The furnace may be sealed tight during the entire melting period, and since the electric arc consumes the oxygen of the air in the furnace chamber before any of the metal becomes molten, the occurrence of any appreciable loss through oxidation is rendered quite impossible.

Further, the furnace is ideally adapted to mechanical charging and pouring, which, of course, is in itself a notable factor in securing maximum production with minimum cost. Thus, in the "direct pouring," Detroit type designed more especially for rolling mill service, metal is poured direct from the furnace into moulds, thus eliminating double pouring,

and with mechanical charging, as high as 22 to 24 tons of yellow brass can be produced by this remarkable appliance. If, however, it is undesirable or inexpedient to go the length of installing a mechanical charging device, the pouring can be done in hand ladles without any difficulty, and is, in fact, much simpler than in coke or oil-fired furnaces. With such a rugged fool-proof machine, free of complicated



A Typical Two-Furnace Detroit Installation

devices, ideal operating conditions are attained.

This is exemplified in the operating results reached. With heats of 2,000 pounds of yellow brass (60 cu., 40 zn.) melted in 40 minutes, test bars have shown a tensile strength of 50,000 pounds upward. The net metallic loss also was only 1.02 per cent by weight, as between metal charged and metal poured. Again, for instance, the copper content of the first 25 pound ingot of a given 2,000 pound charge, pouring from the furnace into a 250 pound ladle and thence into ingot moulds varied from the copper content of the last ladle by only 0.14 per cent. The first ingot was 59.78, and the last 59.64 copper. It is needless to dwell on the value of such uniformity. As to economy in melting brass alloys and non-ferrous metals generally, the Detroit rocking furnace is without equal, melting yellow brass (60-40) scrap or ingot with a net metallic loss as already noted, of less than one per cent; red brass scrap can be handled for only 0.5 per cent loss; while even yellow, oily borings, turnings or grindings can be satisfactorily disposed of, in common daily routine, at a net metallic loss of less than 2 per cent.

Moreover, as pointed out by Mr. H. M. St. John in his highly instructive paper before the American Electrochemical Society, "brass melted in the electric furnace is practically free from metallic-oxide drosses, and has no opportunity to pick up sulphur or other contaminations from combustion gases. . . . Those furnaces which stir the bath have a considerable advantage in that they produce metal of a remarkably uniform and homogeneous composition. This is a particularly important point in the melting of high-lead alloys, which can be melted in the rocking arc furnace without the use of additional stirring."

Finally, as to low consumption of electrical energy, the current used on the average, in a minimum of 8 to 10 hours, is only 240 kw. hours per short ton for yellow brass, and in 24 hour operation, as low as 200 kw. hours per ton, or even less, is secured. The rapid adoption of the furnace needs no further explanation, for as has been well said, the whole process of its evolution was based on a general principle, which is both universal and progressive.

THE ELECTRIC FURNACE COMPANY

The Electric Furnace Company was organized in 1911 to take over and complete the development of electric furnaces for heating and annealing started by Thaddeus F. Baily, in 1908, and operating under the name of the Baily Engineering Co.

The first experimental work was done on forging furnaces at the plant of the Transue-Williams Forging Corporation, but the work at this plant progressed slowly. However, even with the intermittent attention that could be given this work and the small amount of funds available to carry it on, the development proceeded to a point where a small furnace of 40 kw. capacity was able to run for several days at a time, taking care of the heating requirements for a 1,200 pound steam hammer.

It soon developed, however, that the precise design of furnace used in these experiments was not rugged enough to justify its use in commercial practice, and experiments at this plant and on this design of furnace were abandoned. The results accomplished indicated, however, that a successful and commercially feasible product could be developed with certain modifications of design that had presented themselves during the early experiments.

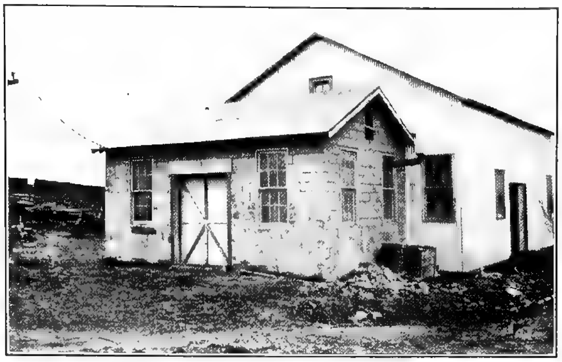
About this time there arose a demand for electric annealing and heat treating furnaces, the operating temperature of these furnaces being very much lower than in forging furnaces, which seemed to indicate that one of the earlier difficulties of the forge furnace, namely the trouble with refractories, would be eliminated in the annealing furnace design.

The first of the modified types of furnace, built for annealing purposes, was installed at the plant of the Wm. A. Rogers Co., Niagara Falls, N. Y., for the annealing of silverware blanks. This was the first of the continuous pusher type of furnace built, and still remains the standard type for all the later equipment built by the company.

The period of development of the furnaces and the installation of the first commercial units was attended by the usual difficulties, due to lack of adequate financing, the skepticism of the trade generally, as well as the mechanical and electrical difficulties accompanying the development of any new design; and it is almost impossible to conceive how this period could have been carried through without the financial assistance of Mrs. Elizabeth A. Harter, of Canton, O., whose courage and belief in the ultimate success of the business continued throughout the long disheartening period of development. When substantially all other investors in the early stock of the company withdrew their support, she came to the assistance of the company on every critical occasion.

The First Baily Electric Furnace, a Forging Furnace at the Plant of the Transue-Williams Corporation

In engineering questions the company, since shortly after its organization, was fortunate in having Frank T. Cope, the present vice president of the company, whose engineering ability has contributed largely to the development of the present type of equipment. Mention must also be made of the loyalty of those employees, who, under the most trying circumstances, and often for months without their regular pay, contributed their best efforts during this period, not only in the design and manufacture of the equipment, but in its erection and operation.



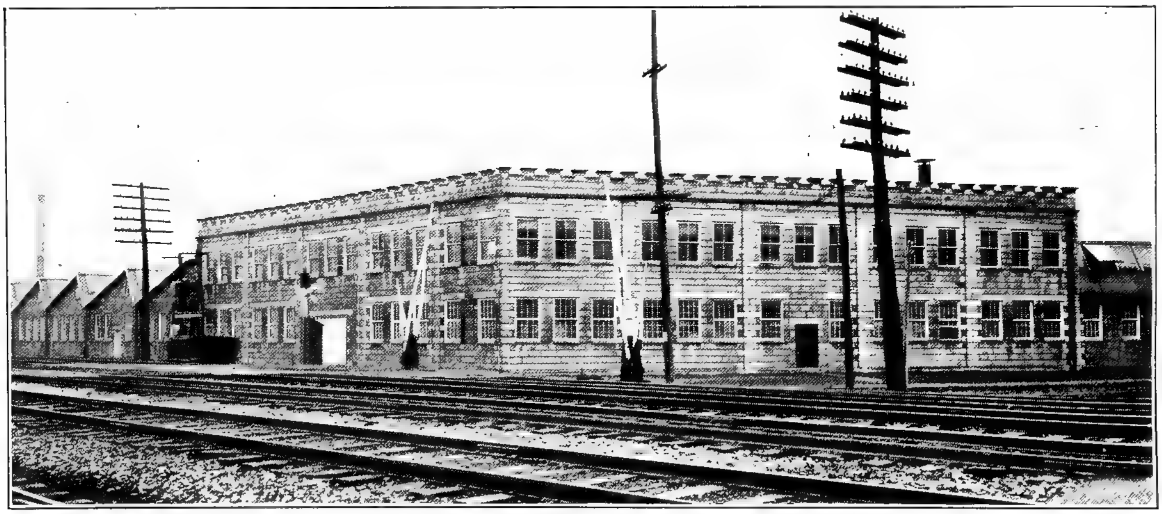
The First Home of the Electric Furnace Company, Where the Early Experiments Were Made

In one of the critical financial periods of the Company, Mr. J. J. Haas, of Washington, D. C., came to its assistance, not only furnishing funds himself, but arranging the sale of stock of the company to a number of his friends. Through the sale of additional securities in 1916 through the Cleveland Industrial Development Co., of Cleveland, O., the Company became associated with the late Mr. S. T. Wellman, then chairman of the board of The Wellman-Seaver-Morgan Co., who in 1918 became a director of The Electric Furnace Co., and his counsel and interest in engineering matters was of great value.

The company was also fortunate, during the early connection with the Cleveland group of stockholders in interesting Mr. Samuel Scovil, of the Cleveland Electric Illuminating Co., who is still interested in the company, and Mr. R. B. Newcomb, also of Cleveland, whose financial support, on more than one occasion, was the means of continuing without interruption the development of the business.

The first heat-treating installation of note was furnished to the National Malleable Castings Co., of Sharon, Pa., in 1914, for the heat treatment of drawbar knuckles, and was the first use of automatic heat treating equipment, controlling not only the rate of movement and temperature through both the hardening and drawing furnace, but also the time of the material in the quench, and the temperature of the quenching bath. Though there have been a number of duplicates of this equipment installed since that time, it represents the highest type of development for heat treating that has so far been brought forth. During the Great War duplicates of this equipment were furnished to the Ingalls-Shepard Forging Co., Harvey, Ill., for the treatment of Liberty motor airplane crankshafts, and to the National Malleable Castings Company's Cleveland plant for the heat treatment of cast steel anchor chain.

Another type of furnace embodying radical features of design is the recuperative car type annealing furnace especially adapted to large tonnages where slow heating and slow cooling of the material is required. The cars, in this case, are



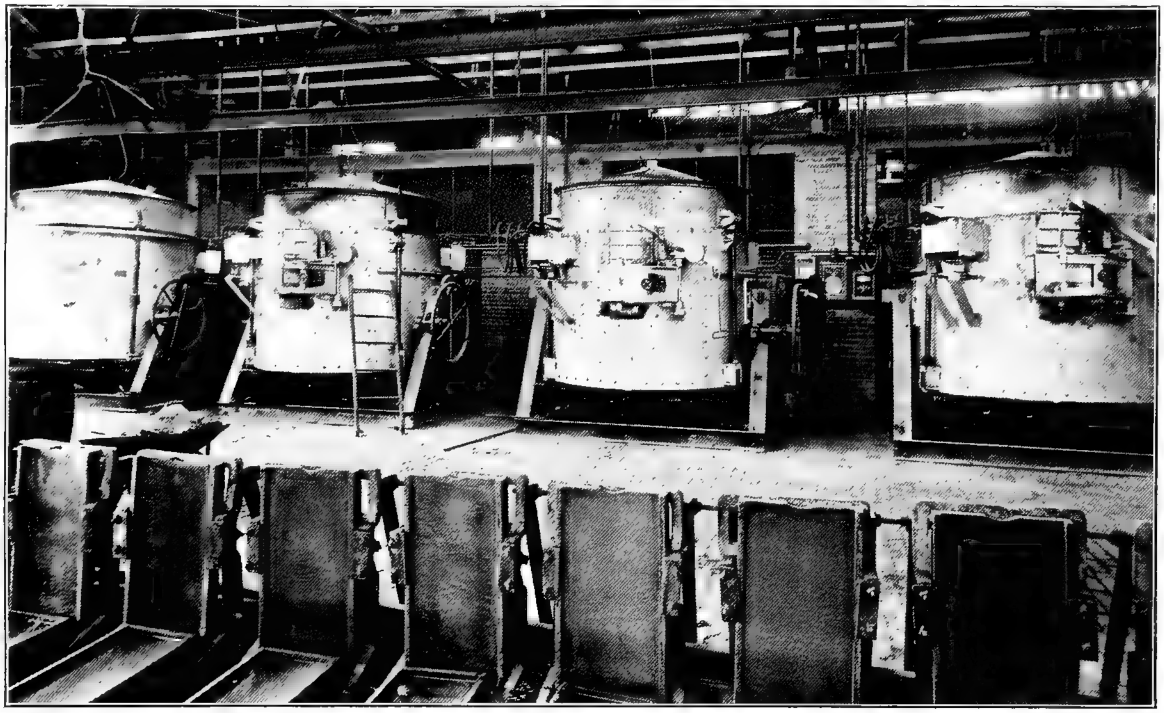
The Present Plant of the Electric Furnace Company at Salem, Ohio, where the Baily Furnaces and Transformers are Manufactured

located on two lines of track going through the furnace and passing each other in opposite directions, the heating chamber proper being in the center of the furnace, the material coming to full heat at that point; and as it passes out through the long recuperative hood gives up a large part of its heat to the cold incoming material. The first of these furnaces was installed at the plant of the Morris & Bailey Steel Company, Wilson, Pa., and has a rated capacity of 150 tons per day. The second installation is at the Braeburn Steel Co., Braeburn, Pa., for the annealing of high carbon, high chrome steel for ball races, and has a capacity of 35 tons per day when annealing material requiring a 40 hour soak at maximum temperature, and twice this capacity when soaking at maximum temperature for a 2-hour period.

There have been more than thirty of these annealing furnace equipments built throughout this country and abroad, with an aggregate electrical capacity of 9,000 kw. and whose producing capacity aggregates the striking total of more than 240,000 tons a year.

In 1916 the company produced the first commercial non-ferrous melting furnace, which was installed in the plant of the Aluminum Co. of America at Niagara Falls, for the melting of aluminum. This furnace while successful from an operating standpoint was later abandoned by the Aluminum Company, and through The Electric Furnace Co., resold to the Lumen Bearing Company of Buffalo for the melting of their alloy called "Lumen." It has been in continuous operation ever since. Two similar units of the same size have since been installed in their plant. With slight modifications of mechanical features there have been more than sixty duplicates of this equipment built throughout this country and abroad with an aggregate electrical capacity of 7,000 kw. and a melting capacity of 200,000 tons a year.

In 1918 the company moved its works from Alliance, Ohio, where it had inadequate plant facilities, to Salem, Ohio, where it now has a plant of 70,000 sq. ft., and nearly 10 acres of ground, and where it manufactures all of its transformers, machine parts and switching gear.



Four Baily Electric Melting Furnaces Installed in a Large Smelter for Making Rolling Mill Slab of Yellow Brass

THADDEUS FRANCIS BAILY

Thaddeus Francis Baily, whose labors made possible the Electric Furnace Company, and who occupies the position of president and general manager, was born at Beloit, Ohio, January 19, 1883. He was in attendance at the Mt. Union College, Alliance, Ohio, for two years at which time he was a member of the Alpha Tau Omega Fraternity. Ambitious to get started in the business world he began work in his father's hardware store at Beloit. Here he was inspired to better things than a country hardware store through the reading of *Iron Age* and other engineering publications; and during his two years at college he became further interested in engineering through the technical magazines he found there. In 1905 he left college and started the Baily Engineering Company, at Alliance, which company had for its purpose the selling of engines, boilers, and power plant equipment, as well as the designing and construction of isolated power houses and lighting systems.

Mr. Baily became interested in electrical furnaces when trying to sell a low-pressure steam turbine plant in a drop forge plant. He learned then that the prospective customer could not use all the power he would so recover. He tried to find an electric furnace suitable for heating forging stock in order that he might sell the turbine equipment, but discovered that such a furnace was not being built either in this country or abroad. This led him to experimental work on heating furnaces which resulted in the development of the resistance type now known to the trade as "Baily" furnaces and recognised as already standard in an art yet young.

In 1915, in association with Mr. F. T. Cope, he designed and constructed, through the Electric Furnace Company organization, the automatic heat treating furnaces for the National Malleable Castings Co. at Sharon, Pa., thus gaining the incentive which later was availed of and utilized in the Electric Furnace Company as described above.

Mr. Baily is of Quaker ancestry and is particularly interested in economics and research in casting metals. He is a member of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, American Electro-Chemical Society, American Iron and Steel Institute, American Society for the Advancement of Science, American Foundrymen's Association, American Society for Testing Materials, American Institute of Mining and Metallurgical Engineers, American Institute of Iron & Steel Electrical Engineers, the Electrical League of Cleveland, Ohio, and the Chemists' Club of New York City.

THADDEUS F. BAILY

CHAPTER XIV

STORY OF ELECTRICAL TABULATING AND ACCOUNTING AND OF THE ELECTRICAL TIME RECORDER

Origin

ABOUT the close of the compilation of the 10th U. S. Census (1880) the attention of Dr. Herman Hollerith, an engineer, who, as a special agent of the 10th Census, had won early recognition as an exceptionally able and accomplished statistician, was drawn to the need of mechanical aids for census tabulation. For this purpose Dr. Hollerith developed a system of recording the descriptive data for each individual, or each unit of inquiry, by punching holes in strips of paper or cards which could be adapted to control electrical mechanisms in the form of counting or adding devices, either singly or in desired combinations. The first practical utilization of this machine and the machinery devised for its application was in the tabulation of mortality statistics in the City of Baltimore, and they were also used by the Bureau of Vital Statistics of New Jersey and by the Board of Health of New York City.

The first patents to Dr. Hollerith on this system were issued in 1889, and the claim of one of these patents describes the basic idea of the apparatus then used and of all the subsequent applications of the system, as consisting of recording separate statistical items pertaining to the individual by means of holes, or combinations of holes, punched in sheets of electrically non-conducting material and bearing a specific relation to each other and to a standard; and then counting or tallying such statistical items either separately or in combination by means of electrical counters operated by electro-magnets, the circuits through which were controlled by the perforated cards.

The essential idea is that of a principle or method of tabulation, rather than of a particular machine for the utilization of any principle or method. In order to arrive at any adequate comprehension of the value of this invention, it is necessary to remember that it starts with the recording of facts in a manner which permits the utilization of the records thus obtained—that is the punched cards—as means for the direct and immediate control of any kind of counting or computing machinery.

The electrical current is doubtless the best medium for effecting this control, but it is by no means the sole available medium.

First Extensive Use

At the beginning of the organization for the 11th U. S. Census (1890), the Superintendent of Census appointed a commission of three of the most experienced statisticians in the United States to make a practical test of all systems of tabulation that might be offered for use in connection with that Census. The report of this commission (November 30, 1889) showed that three methods were offered in competition and thoroughly tested, the commission reporting that the punching could be done more rapidly than by writing on slips, and that the tabulating by machine was

about eight times as rapid as by sorting slips, as well as being decidedly more accurate.*

As a result of this report, Dr. Hollerith was awarded a contract for furnishing the equipment for tabulating the returns of the 11th Census.

In the operation of the system as applied to the population and mortality statistics in that Census, the cards were perforated in a machine known as the keyboard punch. This machine was about the size of a typewriter, having in front a perforated board bearing letter or figure characters beside each hole, corresponding to the index positions of the card. Over this key-board swung an index finder whose movement, after the manner of a pantograph, was repeated in the rear by a punch. The movement of the punch was limited between two guides, upon which the cards were placed. The key-board had a number of rows of holes and each hole had its designated lettering or number corresponding to the inquiry and answer respecting a person or unit. When the index finger was pressed down in any one of these holes, the punch in the back cut out the corresponding hole in the Manila card.

The apparatus in which the items punched in the cards were tallied or counted consisted of three parts, namely, the press or circuit-closing device; the dials or counters; and the sorting box.

The press consisted of a hard-rubber bed-plate provided with suitable stops or guides against which the cards were successively placed. The bed-plate was formed with a number of holes or cups corresponding in number and arrangement with the holes that may be punched on the card. Each cup was partly filled with mercury and connected with a binding post on the back of the frame. Above the hard-rubber plate was a reciprocating box provided with a number of projecting spring-actuated contact points corresponding in position with the centers of the mercury cups. When a card was placed in the press and the handle was brought down, these pins formed circuits corresponding to the punched record.

Arranged in a suitable frame was a number of dial counters, each capable of registering to 10,000. These counters were actuated by electro-magnets terminating in binding posts on the back of the counter-frame.

To tabulate any of the facts recorded on the cards, it was only necessary to connect the corresponding binding posts with the binding posts of the counters and then pass the cards one by one through the press, when the results were shown directly on the counters. The number of facts thus recorded at any one operation was only limited by the number of counters used.

If, while certain facts were being tabulated, it was desirable at the same time to sort or arrange the cards according to any data, as for example, nationality, a sorting box was employed. This sorting box as used was suitably divided into twenty-four compartments, each of which was closed by a lid, held against the tension of a spring by a catch which formed the armature of a suitable magnet. If desired, the number of compartments could have been greater. These magnets were connected with the binding posts of the press according to the data by which the cards were to be assorted. When a card was put in the press, the armature corresponding with the given record was attracted, thus releasing the corresponding lid, which remained open until the card was deposited in that division and the lid again closed by hand. This was done with the right hand while with the left hand another card was being put in position in the press. The sides of the sorting box were hinged to permit the easy removal of the cards when assorted. The sorting of the cards was done while, at the same time, counting any desired group or groups of facts.

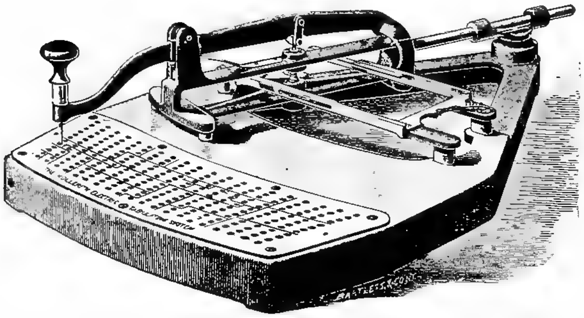
First Application of Electrical Machines for Aggregating Amounts

In the compilation of Census statistics, such as those of population, mortality, etc., or the bulk of the work to which the Hol-

* For details of the report and a description of U. S. Census Office work, see "Counting a Nation by Electricity," by T. C. Martin, *Electrical Engineer,* Vol. XII, No. 184. November 11, 1891, pp. 521-530.

lerith apparatus had been applied, the person formed the unit, so that each card represented simply that unit.

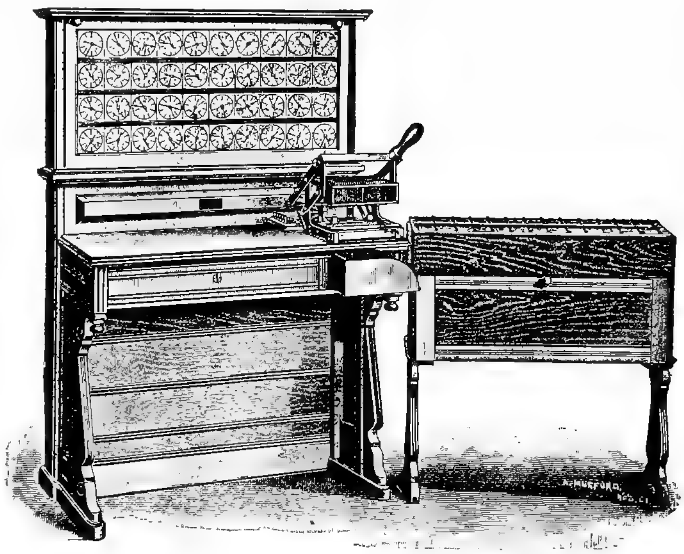
But the Census included agricultural, manufacturing and similar statistics, and



The Keyboard Punch

it was evident that in the figures of agriculture or manufacture, while a card might represent a farm or a factory unit, the *value* of the unit might vary greatly. Thus it might be a farm of a hundred acres or of five hundred, and we would thus have to record *amounts*. To accomplish this the so-called "integrating machine" was developed, so that when the punched cards entered the Tabulating Machine, a dial would be energized and would operate not merely once, as in the ordinary population statistics, but would count from one to nine, according to the value of the hole, the counting being determined, as before, by the location of the hole. The device consisted, broadly, in a cylinder around whose circumference studs were set, spring contact points connected to the mercury cups of the press, a motor for revolving the cylinder in conjunction with a train of ordinary registering mechanism, and a device for starting the motor so that the cylinder made one revolution. The operation can be readily understood. A card being put in the press, the circuit was closed through a given counter to the battery, to the cylinder of the integrating device, from one of the nine contact strips of the integrator through the corresponding mercury cup uncovered by the punched hole of the card through the plunger of the pin box corresponding to that hole, and back to the counter. At the same time another circuit was closed through the magnet, when the handle was brought down, which allowed the train to revolve the cylinder of the integrating device one revolution. During that revolution the circuit through the dial counter was made and broken from one to nine times according to the contact strip which was brought into operation. The registration thus secured gave the totals from any number of different sizes or amounts, and the device was the predecessor of the Tabulating Machine as used so extensively at the present day for railroad accounting, sales analysis, shop cost accounting and similar purposes.

During the process of tabulating the 11th Census (1890) the attention of Dr. Hollerith was called to the need of some machine or device to aid in the audit of



Population Type Tabulating Machine with Sorting Box

railroad freight accounts and to the compilation of the commodity statistics. To accomplish this, the system of punched card tabulation with the integrating tabulator as described was employed, experiment being made at the office of the Auditor of Freight Accounts of the New York Central and Hudson River Railroad Com-

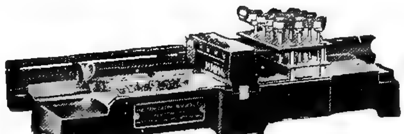
pany. This device proved that the work could be done to advantage by this method. In the application of this system to railroad and commercial accounting, it was found desirable also to make radical changes in the apparatus for punching the card as well as in the apparatus upon which the amounts were recorded.

One of the first units of the Hollerith system to be changed was the device for perforating the cards. In the pantograph type of punch previously described, the fields or groups of characters on the card were arranged for the convenience of the pantograph punch in a sequence proceeding from the upper left hand corner of the card across the top of the card and then from right to left across the bottom of the card. This was done to facilitate the insertion of the new card and the removal of the punched card.

In the work of preparing cards for use for agricultural, railroad and insurance statistics, and the like, it was much more convenient to have the cards arranged so that the fields would be in vertical columns, as this would facilitate the punching and the reading of the cards, as well as the tabulating. For this purpose the device known as the Key Punch was developed, and while various details of the key punch have been improved, it is substantially the same today in principle as the punch then devised.

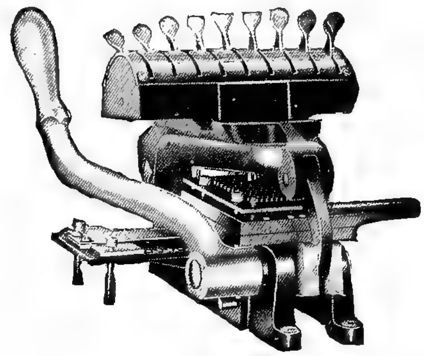
The cards are printed with vertical columns of figures from 0 to 9 (if necessary certain columns may run from 1 to 12) separated by rules into groups of one or more columns called "fields." Each field relates to some one item, such as date, job number, quantity, value, etc. Every fact to be recorded upon the card must be expressed in figures. In business operations most facts are numerical, and it is easy to cast those which are not into numerical form. The right-hand column in a field is units, the next tens, the third hundreds, and upward. Obviously, three columns will permit the punching of any number from 0 to 999. It is only necessary to design the card so that the facts upon the time ticket or invoice may be effectively transcribed to successive fields. When a card is so designed, it will appear that certain fields require addition, such as quantity, number, hours or value, while the others, as date, job, class, operative's number, etc., are of value for sorting,—and when so sorted and passed through the Tabulating Machine, the totals will be simultaneously presented for the figures punched out in the fields requiring addition.

The card-perforating machine developed for preparing the tabulating cards is



The Key Punch

provided with ten punches, each operated by one of the keys numbered from 0 to 9, and an additional punch and key marked X, for the purpose of skipping any given fields which are frequently omitted. The card is inserted in the punch by the clerk and pushed to the right, similarly to the operation of a typewriter, until the first column of the desired field is directly under the punches. Suppose there are three



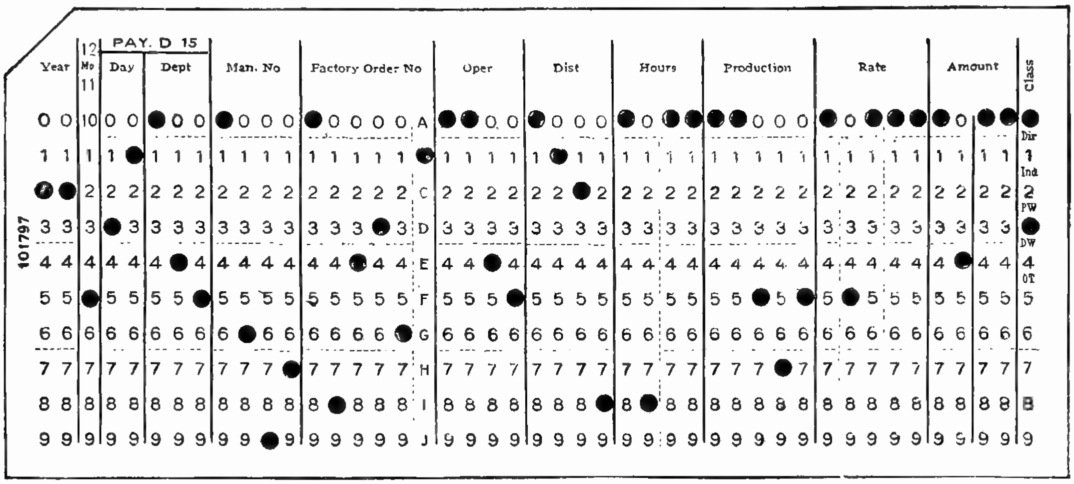
The Gang Punch

columns in this field, and 123 is to be punched. Key 1 is depressed, punching a hole in figure 1 in the first column. Upon the release of this key the machine feeds the card forward to the next column. The operator then strikes Key 2 and punches a hole in figure 2 of that column. The card again feeds forward, and the operator strikes Key 3, punching 3 in that column.

By thus striking in succession the Keys 1, 2 and 3, the number 123 has been punched.

Besides the key punch just described, a "gang" punch is used for punching such facts as are common to a number of cards, as for instance, the department, the month, day, etc. The gang punch is arranged with a number of movable punches, which can be easily changed and set for any desired combination of month, day, etc., and as many as eight or ten cards can be punched for such facts at one operation. The object of the gang punch is to provide a short cut by which several cards may be punched at once, where the same facts are to be recorded in a large number of cards.

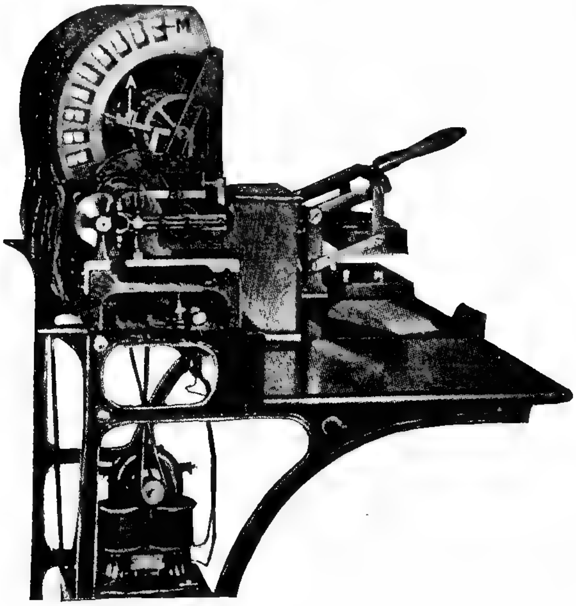
In the type of Tabulating Machine previously used, the counting mechanisms were of the dial type, having two hands. These counters were originally designed to receive one impulse only, or one movement of the unit hand. In the agricultural and commercial statistics, however, it was necessary in recording amounts to give these counters as many as nine impulses, putting the card on the mercury bed-plate and holding down the pin box until the integrating device had completed one cycle. Dr. Hollerith perceived that this mechanism should be improved, both to make the machine more rapid in the action of recording, and to facilitate the reading of the results, and devised the machine by which the result was shown directly in figures upon the counting mechanisms, so that a group of units was at one operation transferred to the adding wheels of the counter. For each adding device (corresponding to a column of the card) there was a series of nine electro-magnets arranged in an arc about the adding wheels. A radial arm swung about the center of the adding wheels and carried a pawl by which it caused the adding wheels to be turned a number of spaces according to the figure to be added. This was done by causing the pawl of the swinging arm to act on the adding wheel sooner or later in the course of its sweep. If it acted directly on starting, it turned the wheel nine spaces and added nine. If it did not act until it had passed the five magnets, it turned the wheel four spaces and added four. The timing of the action of the pawl on the adding wheel, as the arm swung over it, was effected by the segmental series of electro-magnets as follows: Each magnet was connected to the pins of the pin box and the selection of a particular magnet in the arc or curved series of magnets was controlled by the action of the punched card in the pin box, which caused a circuit to be closed through one of the magnets of the curved segment. When a magnet was energized, it released a pawl



The Hollerith Card

in the path of the swinging arm, which striking a trigger on this arm caused the turning pawl of the swinging arm to engage the adding wheel and move it a greater or less number of spaces, according to the position in the arc of the magnet which was energized.

To tabulate a card in one of these machines, the card was placed by the operator beneath the pin box, the pin box depressed and the card removed by hand. If the card was properly punched a bell rang simultaneously with the depression of the



Side View of the Hollerith Tabulating Machine

pin box; and if it was not properly punched, the machine gave notice of the same so that an error could be corrected.

A subsequent development of this type of Tabulating Machine, called the Semi-Automatic, was developed shortly afterwards. In this machine the cards were dropped, one after the other, between two guides corresponding to the pin box, and then added and stacked automatically by the machine. There were but few of these semi-automatic machines built as they were almost immediately followed by the development of the full automatic Tabulating Machine.

First Automatically Feeding Electrical Tabulators and Sorters

During the compilation of the 12th U. S. Census (1900) the automatic feed for Tabulating and Sorting Machines was first successfully used.

The next important development in apparatus for the punched card tabulating system was the development of the automatic Sorting Machine, in which a package of say four or five hundred cards would be put into a feeding mechanism or hopper which would feed the cards automatically one by one into the machine, feed them down, and cause them to be sorted into the twelve hoppers below, according to the position of the hole in the column that was sorted.

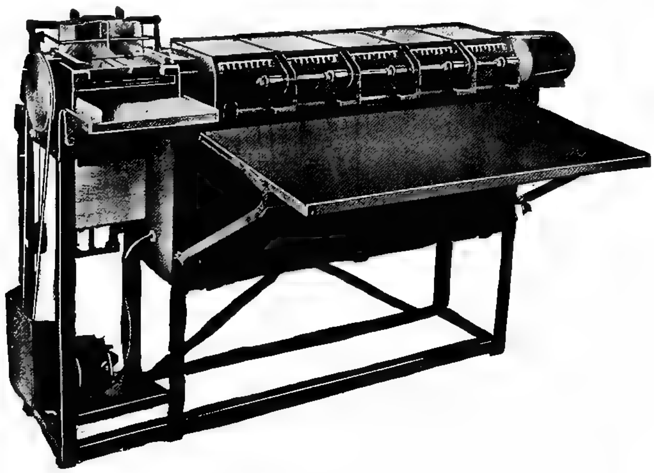
In Tabulating Machines previously described, it was necessary for the operator to place the cards in the machine by hand and to depress the pin box lever with the other hand and then remove by hand the card from under the press. Although the essential principle remained the same, the type of machine was changed so that the cards, instead of being placed in the machine by hand, were fed into a hopper of the machine in lots of four or five hundred cards at a time, and pressed forward by a pressure plate against a knife edge which fed the cards through the machine one at a time at the rate of 150 cards per minute.

As the cards drop down through the feed mechanism they pass between a row of small wire brushes and a row of fixed metal contacts corresponding in position to the columns of the card. When the holes pass between the brushes and the metal contacts, electrical connections are made so that the corresponding magnets in the counters are energized, throwing in clutches that engage the number wheels and carry them forward a distance corresponding to the time the contacts are made. Thus, as the lower position of the card comes in contact first, the contact through a hole in the 9 position of the card will make contact earlier and cause the corresponding number wheel of the counter to be carried forward nine numbers, whereas if the hole in position one of the column is punched, the magnet is not energized

until the cycle of the machine is nearly completed and the number wheel is carried forward only one number.

The machines are made in varying sizes, the ones used generally having five counters, capable of adding simultaneously forty columns of the card, and operate at a speed of 150 cards per minute.

After the cards have actuated the counting mechanism, they are collected or stacked together in a receptacle underneath the feeding mechanism so that they can readily be removed in a stack in the order or sequence in which they were fed to the machine.

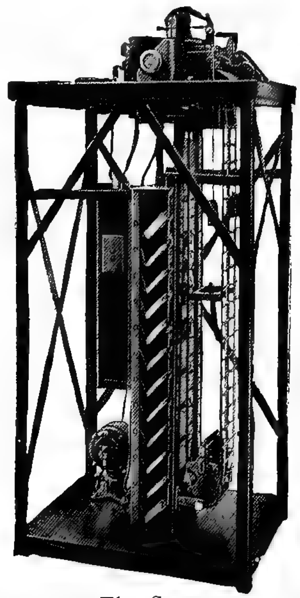


The Tabulating Machine

The automatic Sorting Machine sorts the cards into numerical groups as may be desired. The cards are placed in the feeding mechanism which is similar to that of the Tabulating Machine, and fed downward, one after the other. Below the feeding mechanism there are a series of twelve spring steel chutes, there being twelve chutes or channels corresponding to the twelve vertical number positions in a column of the card, each chute terminating in a receptacle capable of holding about 300 cards.

The cards are sorted one column at a time. The card passes downward between a contact roll and a small wire brush. Where a hole occurs in the column of the card being sorted, the brush contacts with the roll, and the magnet is energized, causing a pawl to catch the lips of the particular chute corresponding to the position of that hole in the card and holding that particular chute open until the card has entered it, the card being carried on by the fingers of an endless belt and dropping into its proper box. The cards are fed through this machine at the rate of from 250 to 270 cards per minute.

The machines as above described are in general use in large accounting offices throughout the world, as well as in many of the U. S. Government Offices. They are



The Sorter

used extensively in the audit of Post Office Money Orders, in the various Navy Yards, in the compilation of the 13th Census and in the Census of Brazil.

Development of Listing and Total Printing Devices

During the decade from 1910 to 1920 many refinements have been added to both the Tabulating and the Sorting Machine, greatly increasing the convenience and usefulness of the machines, the most important of which are probably the automatic control and the total printing and listing features.

The automatic control referred to is a device for stopping the Tabulating Ma-

chine at the end of a group of cards. What it does is virtually to compare each card, as it is passed through the tabulator feed, with its succeeding card, and where the holes in the controlling field differ, the machine is stopped and the total taken. For example, if we are tabulating the record of sales for Salesman No. 125, as soon as the last card for that salesman has passed, the machine automatically prints the total, and then proceeds to tabulate the next group of cards.

The total printing and listing feature is a device for finding the positions of the number or result wheels of the counters and automatically recording these figures upon a sheet.

By an arrangement of switches, the tabulators can be made to list each individual card, where desired, and then print the total, or it operates at a higher speed and prints simply the total of the groups of cards.

As now furnished, with the automatically controlled printing tabulator there is very little for the operator to do but to see that cards are placed in the hopper and removed from the stacker below, for when the last of a given group of cards is fed through, the machine automatically stops, prints the desired totals, clears or resets the machine and resumes the operation of tabulating without in any way being operated by hand.

THE STORY OF THE ELECTRIC TIME RECORDER

It would be more accurate to call these devices "electrically operated time recorders" instead of "electric time recorders." As will be shown later in this article, time recorders, as used at the present time, do not use electricity in the actual making of a time record, but use it as a control or driving medium.

The time recorder used in modern business has grown out of the invention of the Bundy Key Recorder. It is a comparatively recent device. The machines first put into commercial use were made in the latter part of 1890 in Binghamton, N. Y., by the Bundy Manufacturing Co. The original design of the time recorder comprised a clock movement to which were connected type wheels which were adapted to print the hour and minute on a paper tape alongside of the workman's or operator's number. This number was set up by means of a key having lugs of varying lengths, which the workman inserted in the clock, which when turned set up type corresponding with his number and also tripped a printing hammer, printing this number of the tape and alongside an impression of the clock-driven type wheels showing the time the registration was made. The range of this recorder was limited, only 100 men could register, the units and tens making ninety-nine and the cipher making a hundred. This machine was manufactured for the first six months or so. Mr. Willard L. Bundy, the inventor of the recorder, then made changes in the mechanism so that the number of the man was engraved on the lug of the key, and therefore there was no limitation in the number that could register upon a clock. (See Figures 1 and 2).

Under the able management of Mr. Harlow E. Bundy, the business grew, and new recorders and devices were added to the line; and a company incorporated under the title of the International Time Recording Company. By this time different kinds of time recorders were being manufactured, those adapted to print on a card (See Figure No. 3) and known as Card Recorders, and those printing on a large sheet of paper wound on a drum and known as Dial Recorders (See Figure No. 4) being the best known types. Added to this were recorders adapted for use in offices for miscellaneous uses and known as time stamps.

Up to the year 1903 nearly all time recorders were driven by clock movements and were entirely mechanical. The ap-

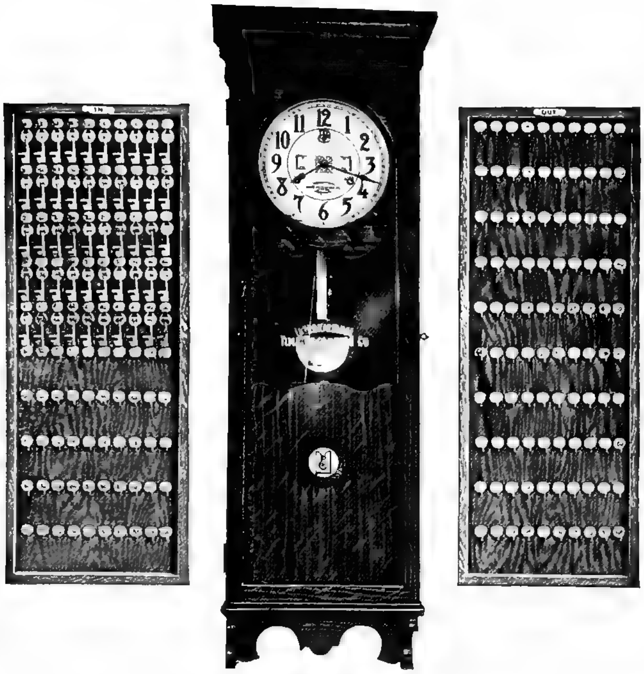


Fig. 1.—Bundy Key Recorder and Key Racks

	6	45	56
	6	49	25
	6	55	98
	7	1	87
	7	4	124
★	12	1	98
★	12	2	87
★	12	3	124
★	12	4	56
★	12	7	25
	12	50	124
	12	52	98
	12	55	87
	12	56	25
	1	3	56
★	6	2	98
★	6	3	87
★	6	5	25
★	6	6	56
★	6	10	124

Fig. 2.—The Bundy Key Recorder

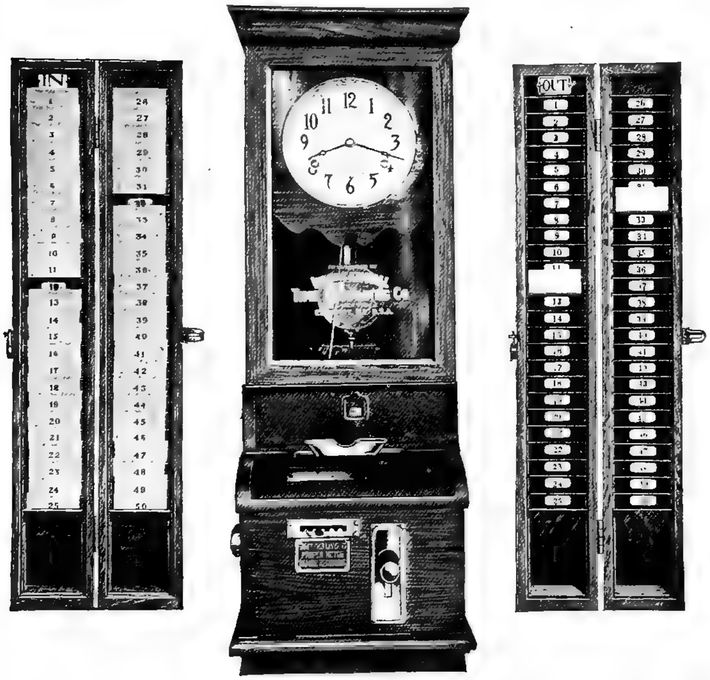


Fig. 3.—International Recorder and Card Racks

plication of electricity to time recorders can hardly be regarded as an invention of any one man. It was more in the nature of a development of the art. The same company that pioneered the time recorder was the first to put electric time recorders to use in a large commercial way.

At this time the possibilities of using electricity in connection with clock systems were beginning to be realized.

The early systems were very simple and consisted for the most part of a good grade of pendulum clock to which a contact was fitted adapted to close for approximately one second each minute. This is termed the master clock. Primary batteries were used, and the electrical part of

the secondary units consisted of an ordinary electro-magnet adapted to move the mechanism forward in minute steps every time the electro-magnet was energized.

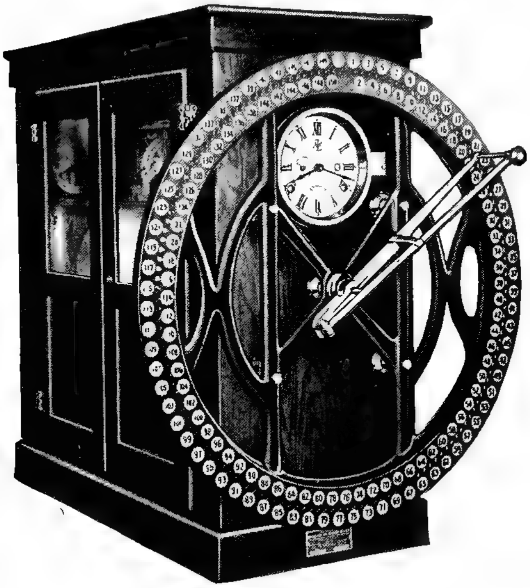


Fig. 4.—Dial Recorder

In the early days most of these systems were operated in series. While such a system is the simplest that can be devised from an electrical standpoint, it was soon found that owing to the need of adding clocks to the system or removing them it was difficult to keep everything in balance, since

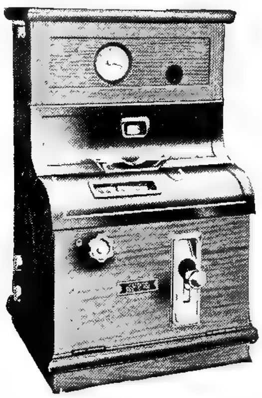


Fig. 5.—1116 Card Recorder (Electrically Operated)

it was necessary to keep the current in the system constant even though the number of clocks were changed.

A further difficulty was encountered when units of different sizes were to be put on the same system, as these required varying amounts of power. This necessitated practically specially designed magnets for each system.

This led to the adoption of the multiple or parallel circuit because of its greater flexibility. It also led to the adoption of relays for the control of various circuits.

It is, of course, apparent that the contacts in the master clock must of necessity be very light in construction and therefore only capable of carrying a very small amount of current. Sparking is also detrimental to these contacts, so the amount of current broken at each impulse must be as small as is practical, and when it is remembered that there are 1440 minutes and therefore 1440 contact closures to be made

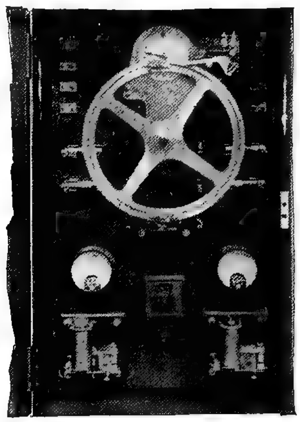


Fig. 6.—"B" Charging Board

every twenty-four hours, it will be seen care in design is necessary from both a mechanical and electrical standpoint.

From the foregoing description it can be seen that a circuit of an electric impulse clock system consists of a number of electro-magnets connected in multiple. Such a circuit is highly inductive and as a result gives a very destructive spark at the contacts where the current is interrupted.

Therefore, as the current requirements of the time systems grew greater, the main current was no longer put through the master clock contacts, but through the contacts of a master relay, and the coils of this relay only were inserted in the master-clock con-

tact circuit. As this current is of but a few milliamperes, it is easily handled and is not destructive to the contacts.

To protect the contacts of the relay, it is usually provided with carbon contacts in addition to the usual metallic contacts. These are so designed that as the relay armature falls back to open the circuit the metallic contacts open first, and then the carbon contacts which take the spark. Various metals have been used for the contacts. Platinum has been used to some extent, but of late silver is preferred on low voltage equipments; and often tungsten is used on those of higher voltage. Various combinations have been used by different manufacturers but the main thing that is to be secured is a clean make and reasonably quick break with low resistance and durability.

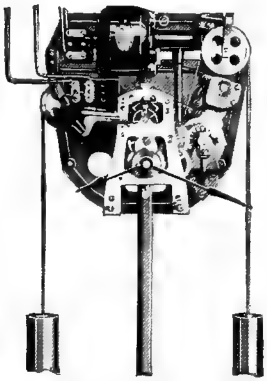


Figure 7.—Mechanism of Type "D" Master Clock

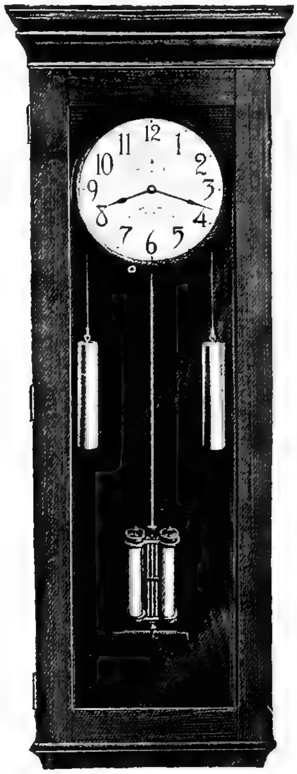


Figure 8.—International Synchronized Master Clock with Mercurial Pendulum

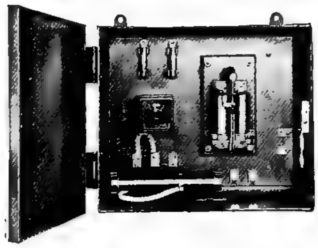


Figure 9.—Master Relay Cabinet

So far as time recorders themselves are concerned, all those operated on the minute impulse plan are simply the same mechanism as those driven by clock movements except that the clock movement is omitted, and a ratchet and pawl movement substituted which is directly connected to the armature of an electro-magnet mounted on the framework of the time recorder. A card time recorder so equipped is shown in Figure No. 5. All other styles of time recorders may be equipped the same way.

In fact, the electric time stamps used today are rapidly gaining in favor and are being more and more widely used.

It is well understood that with each swing of the pendulum of a clock the escape wheel is allowed to move forward one tooth. In electrically controlled time systems, sometimes the pendulum and escapement are removed from the clock and an electromagnet and special escapement used in their place, whereby at each impulse the clock works are allowed to move forward one minute, each time the magnet is energized by the master clock. It takes very little power to do this. The clock is wound up in the usual way by means of a key, and the clock springs drive the recorder mechanism; the electric part simply serving to permit the clock works to advance at the proper time. These clocks are known as electrically escaped clocks.

In the foregoing description of an electric clock system, it will be seen that electricity is used as the motive power to drive all the secondary units; and in the case of the electrically escaped units, the impulse controls their forward movement so that should there be an interruption in the electric current, all the units of the system will stop.

It is convenient to feed a system of the kind described with current from a direct-current lighting system, but due to the likelihood of interruptions in the current supply on lighting circuits, a storage battery

is almost always used to operate electric time systems of the kind described.

Primary batteries were mentioned as being used on the early clock systems where very small power was necessary. They are in use to some extent today, but their use is very limited owing to the frequency with which they have to be renewed and the cost of so doing.

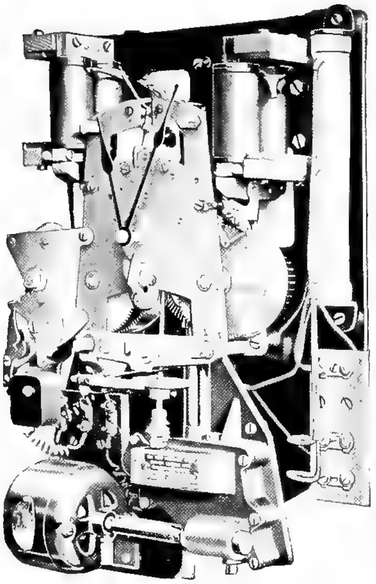


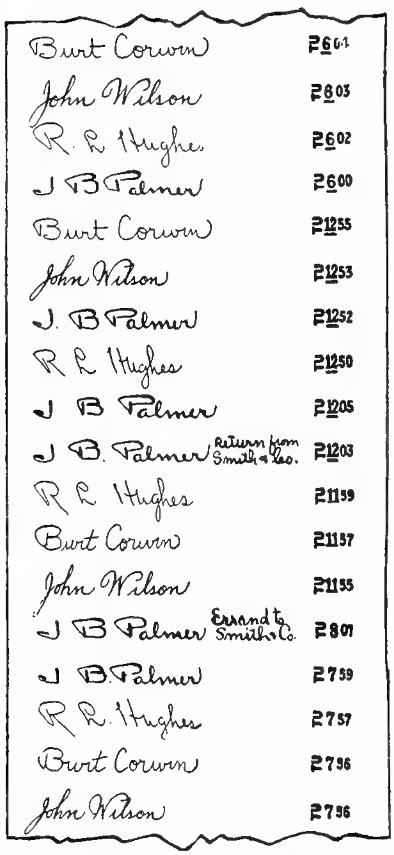
Fig. 10.—Upper Mechanism of Synchronized Card Recorder

Autograph Recorder

The storage batteries are charged from any available lighting or power circuits. If the current supply is direct, it may be done through simple resistance; or if alternating, by means of any of the well known rectifiers or motor generator sets.

Inasmuch as an electric impulse clock system draws an amount of current (ampere-hours) which is known, it is a simple matter to arrange an automatic device to throw the battery on to the charging lines for a sufficient length of time each day to keep it charged. Such automatic charging device may be constructed from a program machine (See Figure No. 6). This consists usually of a wheel or wheels which revolve once in twenty-four hours and are adapted to have pegs or pins fitted to them to operate circuit closers at the desired intervals. Such program devices suitably connected may also be used for ringing signals at any desired intervals as well as operating cut-out devices whereby recorders will move forward only during working hours, etc. Program devices may be driven by a clock movement or stepped forward by an electro-magnet as previously described in connection with time recorders.

There have been a number of other automatic charging devices made from time to time which operate by a relay arrangement closing the charging circuit



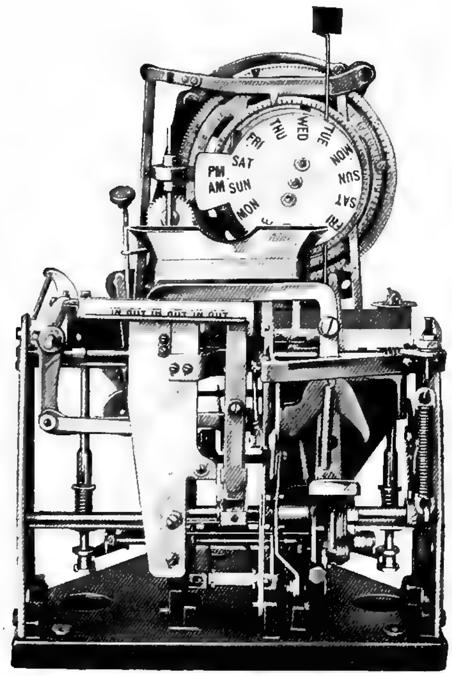
Burt Corwin	6 04
John Wilson	6 03
R. L. Hughes	6 02
J B Palmer	6 00
Burt Corwin	12 55
John Wilson	12 53
J. B Palmer	12 52
R L Hughes	12 50
J B Palmer	12 05
J B. Palmer Return from Smith & Co.	12 03
R L Hughes	11 59
Burt Corwin	11 57
John Wilson	11 55
J B Palmer Errand to Smith & Co.	8 01
J B. Palmer	7 59
R L. Hughes	7 57
Burt Corwin	7 56
John Wilson	7 56

Autograph Record, Reduced in Size. Read from Bottom Up

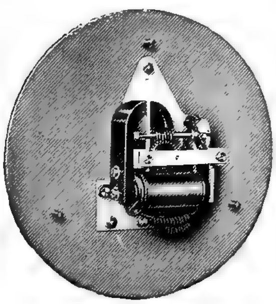
when the fall of potential across the battery reaches a predetermined point, etc. Actual practical use, however, has demonstrated that for clock systems of the class

described the program method or similar arrangement is reliable, simple and rugged.

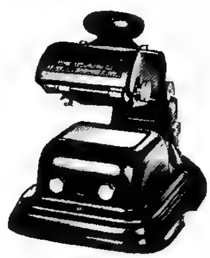
Due to the fact that electric impulse systems require an uninterrupted supply of electric current, storage batteries and their attendant charging devices are almost always required. This means a considerable initial expense in connection with installation and maintenance of the battery after installation. Extension of the system or alteration of its layout after installation usually means interruption of its time keeping.



Lower Mechanism of Card Recorder



Rear View of Secondary Clock Showing Polarized Movement



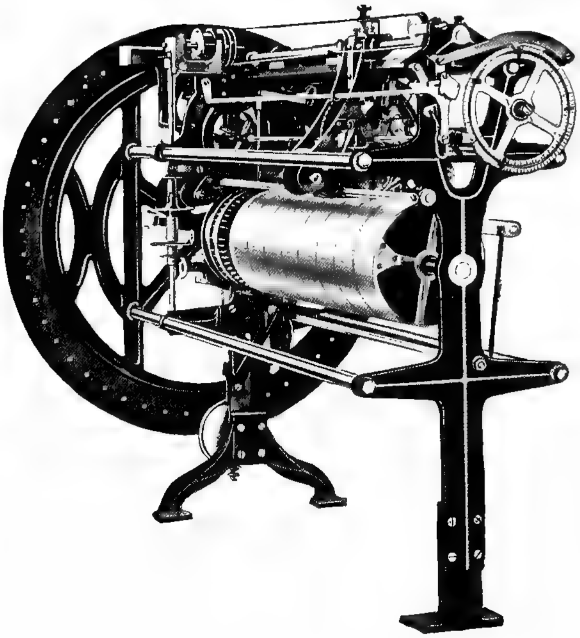
Time Stamp

To provide an electric time system that would avoid these difficulties, do away with batteries and enable the use of the ordinary commercial electric light supply for operating the clock system, the International Time Recording Co. brought out in 1918 an electric synchronized system.

This system consists of a self-winding master clock of the weight-driven type which controls the opening and closing of a master relay, through which the system is controlled. (See Figures, 7, 8 and 9).

The other units of the system such as wall clocks, time recorders, program devices, etc., each have a clock movement which is self-winding. These clock movements are fitted with a stopping and an accelerating device whereby the clock may be stopped once an hour if fast, and allowed to run forward and catch up if slow. (See Figure No. 10). As the clock movements are adapted to run several days or more with one winding (from its own electric motor) it follows that even if the synchronizing current sent through the

International Electric Synchronized Fully Automatic Card Recorder



Interior Mechanism Dial Recorder, Showing Dial Sheet Record on Drum

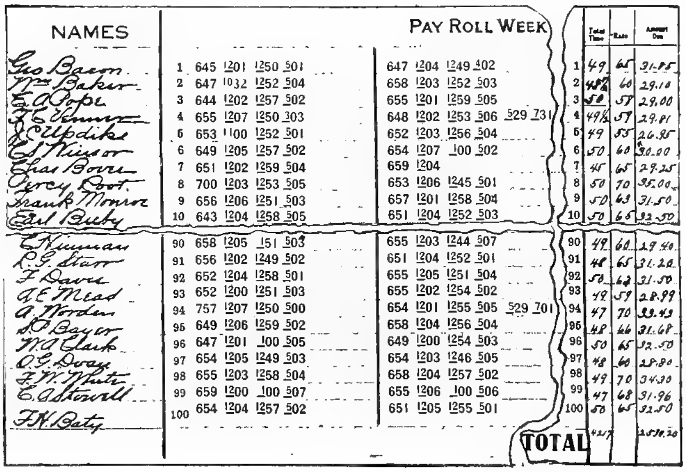
master clock fails and the winding current also, the individual units will all continue to run independently. This system is designed to operate on alternating current of all commercial frequencies as well as on direct current.

It does not synchronize the clocks with just one impulse every hour, but with a prolonged impulse usually of 15 minutes' duration. This permits of an unusual range of synchronizing. With a fifteen minute impulse it will take care of all clocks on the system up to 15 minutes fast or 15 minutes slow.

The clocks controlled by the master clock are not turned back, which is important, especially when they are connected to recorder mechanisms; they are simply stopped, thus relieving the mechanisms of any undue strain. Similarly if the clocks are slow, the special speed escapement is released by the synchronizing current, permitting the clocks to run ahead with the power of their own springs until they are in time with the master clock. By using this plan, the synchronizing range may be made of any desired length from a fraction of a minute up to an hour or more, if desired. For commercial uses, the half hour range mentioned is ample for even unusually irregular cases.

In short, this most modern of electric clock systems uses electricity for its driving power, and stores the power in springs to take care of interruptions; and also uses electricity as a means for synchronizing or aligning the position of the various units of the system from time to time.

A further advantage is that the contacts on the system operate only once per hour instead of once each minute and do not actually break any current unless the clocks are out of synchronism, that is, out of step with the master clock. Owing to the very small amount of current used by any one clock and the plan of connecting, the wiring necessary for the system is reduced to the minimum.



NAMES		PAY ROLL WEEK			Total Time	Rate	Amount Due
Geo Bacon	1	645 1201 1250 501	647 1204 1249 402	1	49	65	31.85
Wm Baker	2	647 1032 1252 504	658 1203 1252 503	2	48¾	60	29.10
E A Pope	3	644 1202 1257 502	655 1201 1259 505	3	50	58	29.00
F C Venner	4	655 1207 1250 303	648 1202 1253 506 529 731	4	49½	59	29.81
J C Updike	6	653 1100 1252 501	652 1203 1256 504	5	49	55	26.95
Ed Winsor	6	649 1205 1257 502	654 1207 100 502	6	50	60	30.00
Chas Bowe	7	651 1202 1259 504	659 1204	7	45	65	29.25
Percy Root	8	700 1203 1253 505	653 1206 1245 501	8	50	70	35.00
Frank Monroe	9	656 1206 1251 503	657 1201 1258 504	9	50	63	31.50
Earl Buby	10	643 1204 1258 505	651 1204 1252 503	10	50	65	32.50
E Kinman	90	658 1205 151 503	655 1203 1244 507	90	49	60	29.40
R.G. Starr	91	656 1202 1249 502	651 1204 1252 501	91	48	65	31.20
F Davis	92	652 1204 1258 501	655 1205 1251 504	92	50	63	31.50
A E Mead	93	652 1200 1251 503	655 1202 1254 502	93	49	59	28.99
A Worden	94	757 1207 1250 500	654 1201 1255 505 529 701	94	47	70	32.43
S P Bayer	95	649 1206 1259 502	658 1204 1256 504	95	48	66	31.68
M A Clark	96	647 1201 100 505	649 1200 1254 503	96	50	65	32.50
O.G. Doray	97	654 1205 1249 503	654 1203 1246 505	97	48	60	28.80
F.W. White	98	655 1203 1258 504	658 1204 1257 502	98	49	70	34.30
E A Stowell	99	659 1200 100 507	655 1206 100 506	99	47	68	31.96
F.H. Baty	100	654 1204 1257 502	651 1205 1255 501	100	50	65	32.50
				TOTAL	421		2,590.20

Section of Weekly Dial Sheet Record Greatly Reduced

CHAPTER XV

THE STORY OF THE ELECTRIC CLOTHES WASHER AND OF OTHER HOUSEHOLD APPLIANCES

THE LEADING PIONEER MANUFACTURERS

THE LAUN-DRY-ETTE

WE of this age have grown so accustomed to innovations and inventions that we cease to wonder, much less to analyze, these changes that have taken place in all phases of our daily life. If we were to pause and set down chronologically the small details of our daily routine from morning till evening we should find few experiences which could have been duplicated a century—nay, fifty years—ago.

Habits of doing things, and methods which stoutly withstood the assault of centuries, have broken down and disappeared in a single decade. So with methods of washing clothes.

True, there were advances before the present era. But they were slow and deliberate, hundreds of years elapsing before one single transition was complete. When one considers that clothes washing has been done all down through the ages since earliest antiquity, it is surprising how slow has been the improvement.

Americans who were in France during the Great War had many an opportunity to see medieval systems of washing still in use. No doubt, they marvelled and were amazed or amused, and yet the washboard, that familiar household article of American life, is but a short step in advance of the corrugated wooden inclines at the water's edge on which the women of the middle ages or modern Europe have rubbed their soiled linen.

While it is true that in washing, as in other forms of human activity, the progress was slow, it is equally true that the advancement, once started, has fairly leaped through several distinct stages. The advance of electricity made this possible, and particularly was its influence felt in the development of laundrying in the home. The electric washing machine has taken its definite place in the economy of the American home.

Among the first of the electrically operated washing machines was the Dolly type. It consisted of a wooden tub and a disc with pegs placed in such a way that the pegs agitated the clothes in the tub as the disc was revolved. Two other more improved types, the Cylinder and the Oscillator soon made their appearance, both of which aimed at accomplishing the common object of all washing processes, which is to force soapy water through the fabric of the clothes. These machines moved the clothes through the water just as the Dolly type had done. The cylinder washer, as its name implies, consisted of a cylinder, perforated and mounted horizontally inside a tub. The tub was partially filled with water, and the cylinder contain-

ing the dirty clothes revolved. The clothes in the cylinder would travel part way up the arc out of the water and then fall back into the lowest part of the container. Some machines used a cylinder which reversed after it had turned a certain distance in one direction. Others caused their cylinders to turn in one direction only. Some cylinders were made of metal, some of wood.

The oscillating type comprised a single tub which by its rocking movement lifted the clothes above the water line and then permitted them to fall back into the water. Many excellent machines of these types are now to be had.

A fourth classification was the vacuum type which made use of hollow cones or cups which alternately forced soapy water through the fabric and drew it back by suction.

In the early part of 1913 Mr. James B. Kirby of Cleveland, Ohio, an inventor who had achieved considerable success in the electrical appliance field, conceived the idea of an electric washing machine which would go farther than its predecessors in lightening the housewife labors. At that time all washing machines were equipped with wringers. This device, which was a familiar part of hand methods, had been transplanted in its entirety to the electric washing machine. Provision had been made for its operation by the electric motor which drove the washing part of the machine.

Mr. Kirby believed that the wringer was a bad remnant of an earlier period which had been carried over into this electrical setting chiefly because no one had seen a way to eliminate it. For some time the large public laundries had been using electrically driven centrifugal dryers which whirled the water out of the wet garments. Why was this not the solution of the problem? To adapt a method, long accepted commercially, to the domestic washing machine was his work.

Nearly all the washing machines then being built except the vacuum type moved the clothes through the water. Mr. Kirby sought another method. While the modern spirit of improvement was first bestirring itself, someone had introduced the vacuum stamper as a means of washing clothes. This device was simple and effective. It was nothing more complicated than a tin funnel mounted on a kind of broom handle. If the dirty clothes were placed in soapy water in a washtub, the housewife could wash them by grasping the handle and working the funnel up and down upon them. It fulfilled that prime requisite of all washday processes by forcing the water down through the clothes. The vacuum created by the hollow, inverted funnel drew the water back through the garments as the operator started the up-stroke. It was a case of the water moving rather than the clothes. So successful was the vacuum stamper and so much easier than the rubboard method, that it had achieved wide popularity and it had been incorporated with various designs into the washers of the vacuum type. Mr. Kirby sought to combine these well-tried principles of washing and drying in one electrically operated machine of a size and cost suitable for the home. The result was a machine known for a time as the Minute Maid and now as the Laun-Dry-Ette. It created the Laun-Dry-Ette type.

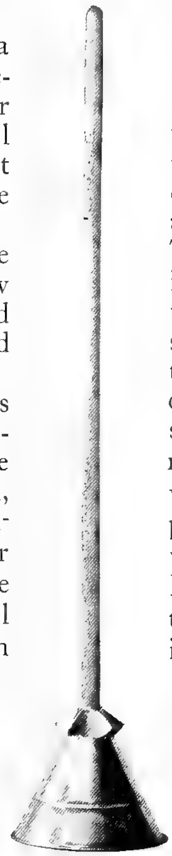


Fig. 1.—The Tin Funnel Which Suggested the Vacuum Cup System of Washing

A company called the Home Specialty Manufacturing Company was organized in 1915 to manufacture this device and chose as its General Manager Mr. F. C. Maxheimer, who had been for some time connected with the National Lamp Works of Cleveland. Later the company changed its name to The Laundryette Mfg. Company, under which it now does business. Increased business forced the company to enlarge its quarters several times until in 1919 a large plant was built in Cleveland. Less than a year later the capacity was increased still further by the addition of another unit.

The Laun-Dry-Ette today consists of a highly polished copper tub, mounted tripod fashion upon three channel-iron legs. Working parts are enclosed by guards below the tub and an electric motor rests upon a platform fastened to the lower part of the frame. The copper tub is tinned on its inner surface.

Fig. 2.—A Commercial Laundry Type of Centrifugal Extractor

Within is a smaller perforated tub which is nickelplated. It rests upon a center shaft, which projects into the outer tub from the mechanism below. The clothes are placed in this inner tub.

At the back of the machine is another shaft, which the motor drives up and down while the washing is done. Attached to the shaft by means of a bracket are two vacuum cups similar in construction to the tin funnel of early days. The movement of the shaft sends the two cups plunging down upon the clothes, driving a stream of soapy water through them. The upward stroke, aided by the suction of the cups, reverses this stream and once more the water courses through the fabric of the dirty garments.

A unique patented fork, working with the bracket gives the cups a decisive eccentric motion while they are down in the water. The inside tub suspended on the shaft, being free to turn, revolves slowly as a result of this impetus so that the clothes are constantly changing their position under the vacuum cups.

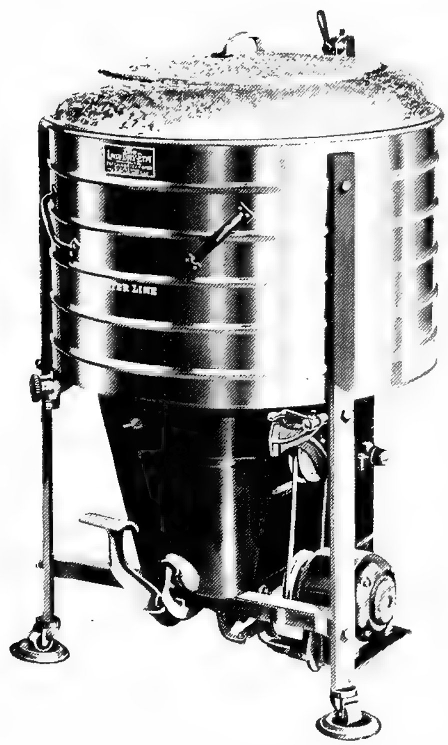


Fig. 3.—The Laun-Dry-Ette

The back shaft makes about 70 strokes a minute, which means that the two cups strike the water that many times. Fifteen minutes is usually required to wash a tubful of clothes. The machine has a capacity of 6 sheets.

Fig. 4.—Wet Clothes Made Wringer-dry in One Minute by the Laun-Dry-Ette

Upon completing the washing operation, the operator lifts the vacuum cups from the back shaft and presses a foot pedal, thus raising the inside tub or dryer containing the clothes above the water level. It whirls for one minute and then the operator stops it. The clothes are wringer dry.

The operator puts them aside in a clothes basket, lowers the dryer and washes the second batch of clothes, making use of the soapy water, which remains in the lower part of the tub. And so with the third tub.

Rinsing follows in the Laun-Dry-Ette and is performed like washing except that only three minutes are required, whereas

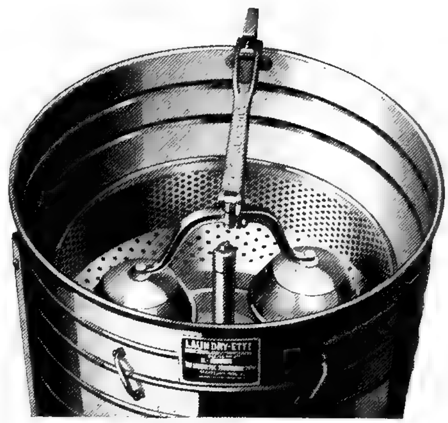


Fig. 5.—The Laun-Dry-Ette with Vacuum Cups Attached

the washing takes fifteen. The clothes are whirled wringer-dry as the rinsing is completed.

With the Laun-Dry-Ette no buttons are torn off or smashed, no hard-to-iron creases put in the clothes.

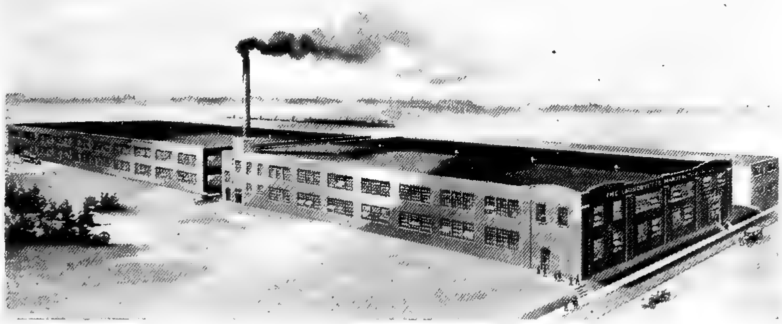


Fig. 6.—The Laun-Dry-Ette Factory at Cleveland

So also, is the bluing done, after which the clothes are ready for the line. At no time in the whole process has it been necessary to put the hands in the water.

The Laun-Dry-Ette, the creator of a new type in electric washing machines, has written another chapter in the "Story of Electricity."

THE COFFIELD ELECTRIC WASHER

DAYTON, OHIO

The electric clothes washer is one of the two or three electrical appliances that are used exclusively by women. The more simple the mechanism of such a machine, and the less attention that mechanism requires, the more satisfaction it gives.

MR. J. L. COFFIELD
President, The Coffield Washer Company

The engineers of The Coffield Washer Company, with twenty years of experience in designing and building nothing but power-driven clothes-washing machines for the home, have consistently striven to build a washer that would give the same dependable service as the motor by which it was operated.

They have even gone further, having designed the machine with self-lubricating bearings throughout, so that the woman using the washer does not even have to think of lubrication or keep an oil can handy. These bearings are triumphs of science, having an amazing long life and secreting their own lubrication, even when worn down to paper thickness after years of service. They are made by a secret process, which requires two years for each bearing.

To illustrate the simplicity of the mechanical part from the standpoint of the woman operator, it is merely necessary to mention that there are only two levers to be used, one for stopping and starting the clothes container, the other for stopping

and starting the wringer. These two handles are so designed that they can be turned in either direction and the desired result accomplished, so there is no confusion in the mind of the operator at any time.

Since the first duty of an electric washer is to wash clothes clean with the minimum of wear on the fabrics, the story of the development of the Coffield washing principle is of prime importance in outlining the history of The Coffield Washer Company. Starting in 1903, the Coffields produced a washing machine of the "Dolly" type, and later, in 1908, brought out a washer of the cylinder type. In the early days these washers were operated by a water motor, hose connected to the faucet of the city water supply; but in 1908 and 1909 the electric motor began to be more seriously considered for use in driving such appliances in the home. The Coffield Company being quick to realize the advantages, especially in that with the electric motor sufficient power could be had to drive the wringer as well, immediately proceeded to develop an electrically operated washing machine in both the Dolly and cylinder types.

From their experience with practically all kinds of washers and their manufacture, the art of washing clothes clean was no mystery to the Coffield people, as, with their various machines, they had been successful in producing washers of the Dolly type, the cylinder type, in which the cylinder revolved continuously in one direction; and the rocking tub or oscillating type, where the clothes container moves back and forth after the manner of a rocking chair. Hence in the ultimate development of the Coffield washer as it is now made, the main effort of its engineers was towards a device that would have mechanism that would stand up indefinitely, whether used merely once a week as in the ordinary home, or for ten hours a day as in some of the smaller domestic laundries. Another very progressive stride was made by the adoption of a motor-driven wringer that was swung to different positions over the washer, tubs and basket. This was the forerunner of Coffield's famous, "obliging" wringer of today.

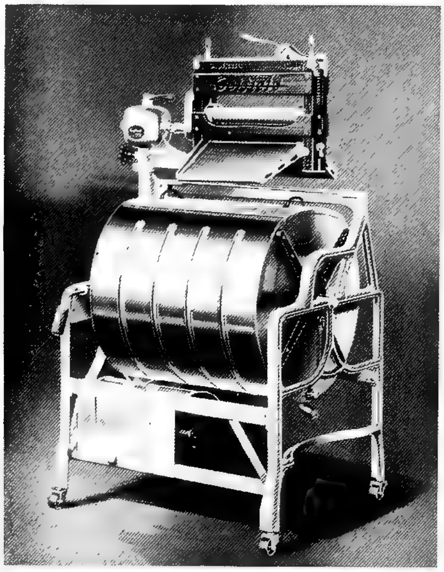


Fig. 1.—The Coffield Electric Washer of 1922

It remained to build up a sales organization, enlarge the manufacturing capacity and let American housekeepers know what the new Coffield electric washer could do for them. Knowing that one user can influence the sales acceptance or resistance of an entire community, all precautions were taken to insure against a single washer being sent out unless it was absolutely correct in workmanship. This had always been a matter of pride with the Coffield builders since the first days of their business.

The value of such ethics was demonstrated. The Coffield electric washer was immediately endowed with the "quality" reputation created by the Coffield water power washer. It was a little hard to convince women that clothes can be washed clean without being violently treated, but home demonstrations quickly proved it.

With everything in favor of the company's rapid expansion into the electrical market, war restrictions suddenly shut off the supply of raw materials. Quotas were based on materials used previously, and since very little had been done by the Coffield Motor Washer Company in the way of actually manufacturing their new electric washer, they were allowed practically nothing with which to go ahead in that department, although the water-power washer business was not seriously cramped by the regulations and restrictions of the War Industries Board.

Thus the company could not produce their new electric washer in any quantities until after the war, when the material restrictions were lifted. Then, with all of their seventeen years of steady, gradual development, armed with experience, reputation and many important patents, the company entered the electric washer market and created an advanced position for themselves right from the start.

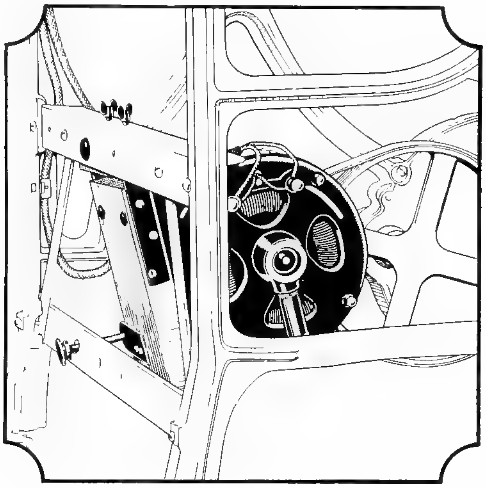


Fig. 2.—The Coffield Motor is Mounted on a Hinged Block, So That the Motor's Weight Swings on the Belt, Thus Acting as Its Own Idler and Taking Up Belt Slack

In 1920 a Canadian plant was established at Hamilton, Ontario. All through the panicky conditions of 1920 and 1921 the company forged ahead. The domestic market was extended, export relations were renewed, noteworthy improvements were made in the washer, and at the time of this writing, February, 1922, the Cof-

field factories are running full time, and sales records are being broken consistently.

The washing action of the Coffield is simply an application of suds in vigorous motion to the clothes. As the copper tub rocks back and forth through a 90 degree arc, nearly a hundred times a minute, the water rushes over the "divide" at the bottom of the tub and most of it dashes upward against the side of the tub, to fall down through the clothes with much force. Another current—an under current—is set up when the water crosses the "divide" and this sweeps back *under* the clothes, turning them over. Some of the advantages are: the clothes are not rubbed or worn in the least; they are not tangled; they are quickly cleaned; it is impossible for oil to creep into the tub and spoil the garments; there are no moving parts to lift out and clean; no crevices to catch and hide soapy scum.

Worthy of special attention is the wringer assembly of the Coffield Electric Washer. It is quite true that the washing principle is most important, but Mr. Coffield was not content merely to "wash well," and therefore set about perfecting a wringer that would be a departure from the ordinary type. He succeeded so well that the Coffield wringer is one of the strong selling points of the machine, since manipulation is greatly simplified. Movable drainboards or chutes are done away with by means of a unique device called "touch o' thumb water shutter."

Some of the construction details of the Coffield deserve close inspection, such as the oilless bearings; the patented drain; the suspension of the quarter-horse motor so as to take up slack in the belt and act

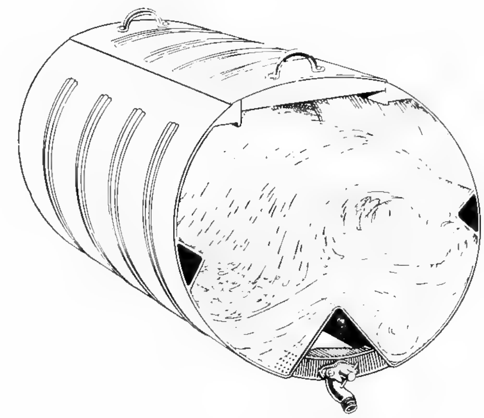


Fig. 3.—The Action of the Suds in the Coffield Tub. This Takes Place Twice in Each Complete Oscillation, or Nearly 100 Times a Minute

as its own idler; the location of all the driving mechanism on one end frame, which also is a patented feature.

It is also interesting to note the results of endurance tests which have been run on the Coffield, in the line of regular duty

Fig. 4.—The Dayton, Ohio, Plant of The Coffield Washer Company, Which Has a Capacity of 7500 Washers Monthly

—as for instance the performance of one washer in a small commercial laundry in Niles, Mich., where it completed the equivalent of over 30 years' average family work without a breakdown. These instances bear out the belief of the officers of the Coffield Washer Company that the only safe, sure growth is a gradual one. It has taken eighteen years to reach their position in the world's market, but it is a wonderfully strong position.

The officers of the company, all of whom are active executives, are as follows: President, J. L. Coffield; Vice-President and General Sales Manager, W. J. Skelton; Vice-President and Plant Superintendent, F. S. Reeve; Secretary-Treasurer, R. E. Coffield.

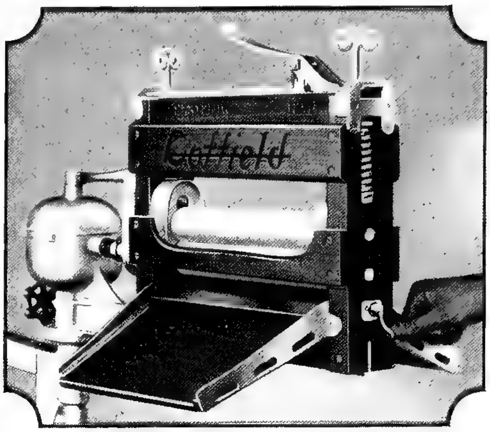


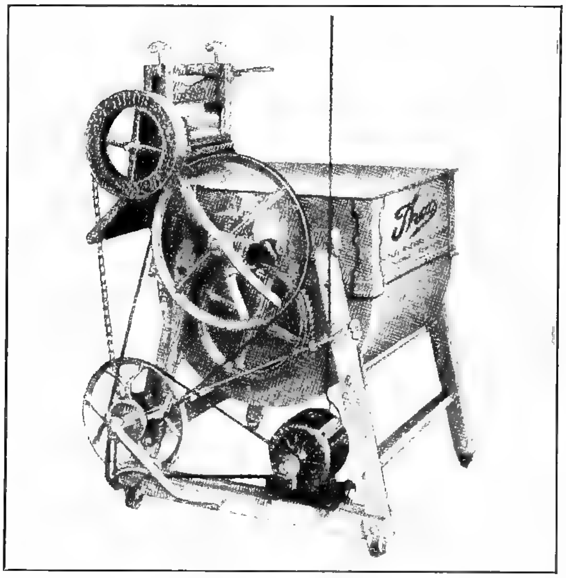
Fig. 5.—Showing One Feature of the Coffield Wringer. The Direction of Wringing Can Be Reversed Instantly with No Adjustment of Drain Boards

THE HURLEY MACHINE COMPANY AND NEIL C. HURLEY, ITS PRESIDENT

We are apt to think of the pioneer work of the electrical industry as having all been done in the field of engineering, but there are stories to be told of the pioneers in the development of the market for electrical appliances, that are no less interesting. The men who first carried the message of electricity to the people, practically expressed in terms of household comfort and labor-saving, were in truth the seed-planters of that great harvest of universal demand that to-day has grown beyond the present powers of the industry to satisfy. One of these early pathfinders, whose work has done much to shape the course of electrical merchandising, is Neil C. Hurley, now president of the Hurley Machine Company of Chicago. It was to his efforts, probably more than those of any other man, that the early popularity of the electric washing machine in the homes of America was due.

Mr. Hurley was born in Galesburg, Ill., on May 3, 1870, of Irish parents. He was one of nine sons, four of whom are now living, all of whom have gained distinction and are prominent in the electrical industry. The elder of the brothers, John D. Hurley, is now president of the Independent Pneumatic Tool Company, of Chicago, and a manufacturer of electric tools. Edward N. Hurley became world-famous as Chairman of the United States Shipping Board during the Great World War and is now chairman of the Board of Directors of the Hurley Machine Company. Myer Hurley, now a vice-president of the Hurley Machine Company, was formerly public utility commissioner of Kansas. All four boys were educated at the public schools in Galesburg, and went to work at an early age in some branch of railroad work.

Neil C. Hurley, when sixteen years old, entered the office of the Chicago, Burlington & Quincy Railroad. Later he shifted to the outside, and for eight months was a locomotive fireman. Then he left the railroad for a while and worked in a Galesburg grocery store. During all this time he went regularly to night school and for a period during the winter each year, he quit work entirely and attended both day



The Original Thor with Belts and Chains

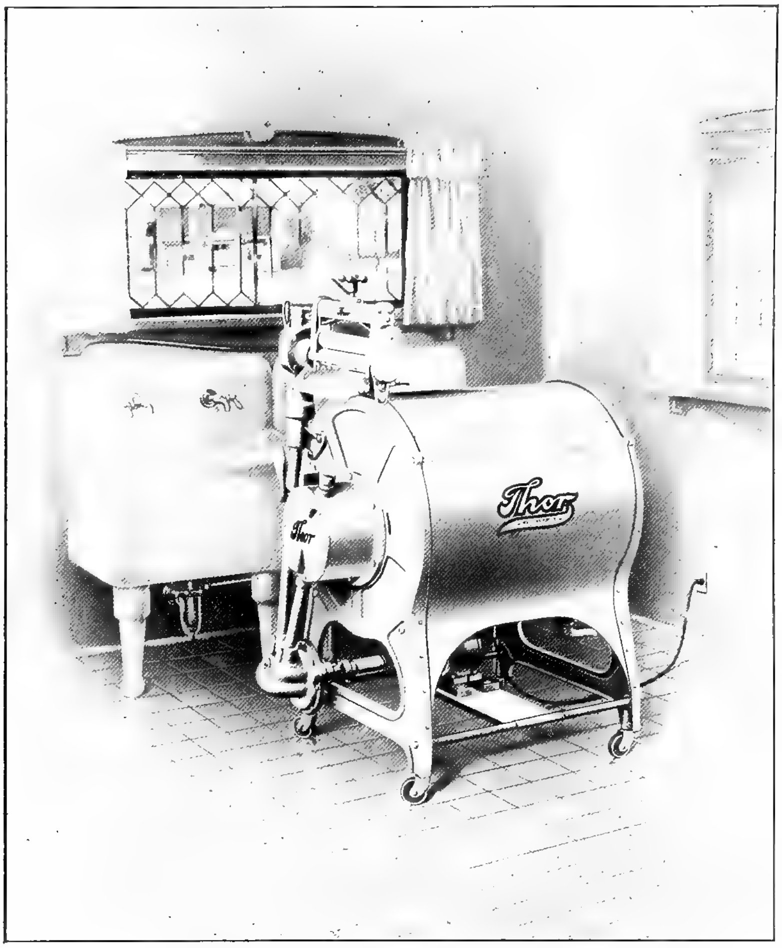
and night school. He was constantly reading at every opportunity and endeavoring to build up his education, a habit which he has maintained to this day.

In 1894, Mr. Hurley entered the railway mail service, running between Rock Island and St. Louis on the Burlington. He was still a postal clerk in 1906, when E. N. Hurley organized the Hurley Ma-

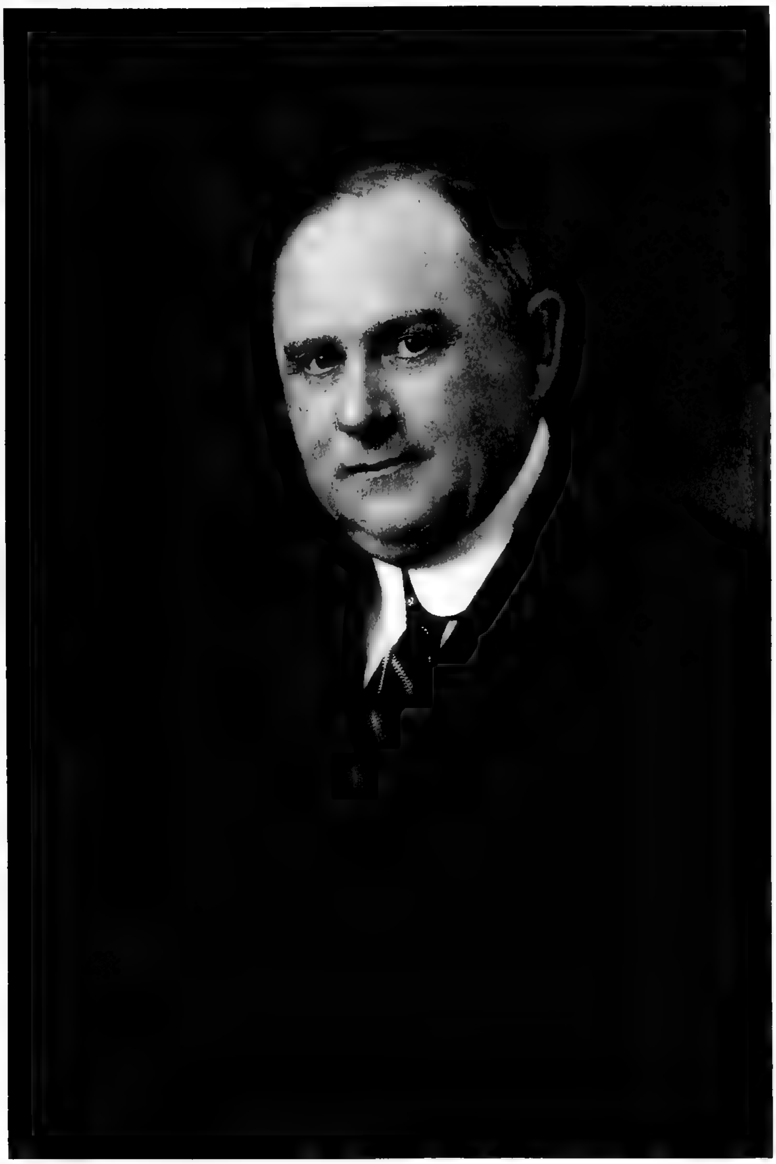
chine Company for the manufacture of floor scraping machines, and Neil Hurley joined the new enterprise as a vice-president. Within a year, the idea of a reversing electric domestic washing machine was conceived and carried through, and Mr. Hurley entered the electrical industry as practically the first active missionary for electric labor-saving in the home.

For the first four years Mr. Hurley was on the road almost continually, visiting central stations throughout the country, preaching the gospel of domestic efficiency and endeavoring to awaken an appreciation of the bigness of the opportunity that lay ahead in the field of household labor-saving. Single washing machines were sold then by dint of persistent and persuasive effort, where today car-load orders are given readily. It was a work of education. No one knew what an electric washing machine was. Not one man in a hundred had the slightest conception of its possibilities.

It was extremely difficult to secure salesmen who could sell washing machines. The first two men who were sent out, failed utterly, came in off the road, and reported that washing machines could not be sold. There simply was no market. After a general talk, Mr. Hurley told them to select the town that they considered hardest; and he would go out and show that the machines could be sold. The two salesmen decided on a town that they were sure offered not a chance. Mr. Hurley got on the train, and called next morning on the central station manager. By rare good



The Perfected Thor of Today

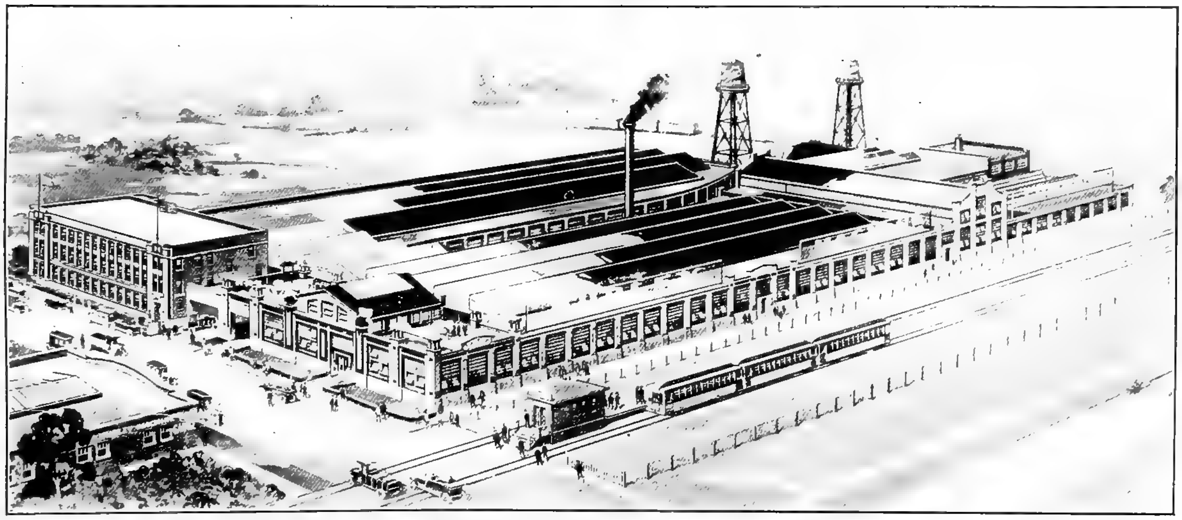


NEIL C. HURLEY

fortune, this man turned out to be an old friend of the family, and the day was spent in visiting, but Hurley went back with an order for six washers in his pocket. This incident made so deep an impression on the two salesmen that they went out again and were successful from that time on.

It was five years after the Thor electric washing machine was put on the market that the Hurley Company devised and perfected an electric ironing machine. Then, in 1914, a vacuum cleaner was added to the line. The Hurley industry has grown since then, until there are now three large factories with over two thousand employees. The American housewife has come to recognize the practical value of electric labor-saving appliances, and the market has grown and broadened until the combined production of all the many manufacturers has been unable to keep up with the demand from all sides. The monthly sales of the Hurley Machine Company are already close onto a million and a half dollars, and additional factories are now being constructed in the effort to keep pace with the rapid spread of this idea which Mr. Hurley began to preach to electrical men, such a short time ago. So persistent has the demand become, that today, 39 per cent. of all the sales from the Chicago Thor Electric Shop are made to people who are not "sold" at all, but voluntarily come in to buy.

Mr. Neil C. Hurley in large measure has brought this all about. He is an untiring worker and has applied a persistent driving force through the years, that has been both inspiring and educational. With it all he possesses unusual qualities for winning confidence and making friends, establishing harmony and maintaining cooperation.



Hurley Machine Company, Chicago
Thor Washers, Home Ironers, and Vacuum Cleaners

Mr. Hurley has a most remarkable memory for names and faces, and he has an acquaintance among electrical men that is phenomenal. Through the years he has been not once, but many times, to every town in the country where there is a central station of any size in operation. The result is that he has built up an exceedingly wide circle of friends, who have placed their confidence in the quality of Thor products from their knowledge of the man behind them. For the outstanding feature of Mr. Hurley's character is an honest simplicity that wins the trust of every man. He is shrewd, yet above all, kindly, helpful, just, dependable and consistent.

Mr. Hurley makes his home in Oak Park, Ill. He is a member of the Chicago Athletic Club, the Union League Club of Chicago, and the Oak Park Country Club.

THE 1900 ELECTRIC WASHER

Many interesting stories are connected with the advances in electric merchandising, but few are equal in suggestiveness and optimistic encouragement to the history of the "1900" electric washer, whose makers with swift decision adopted at a very critical period such a novel and courageous business policy that overnight the company was saved from failure and became a prosperous, profitable, hustling concern.

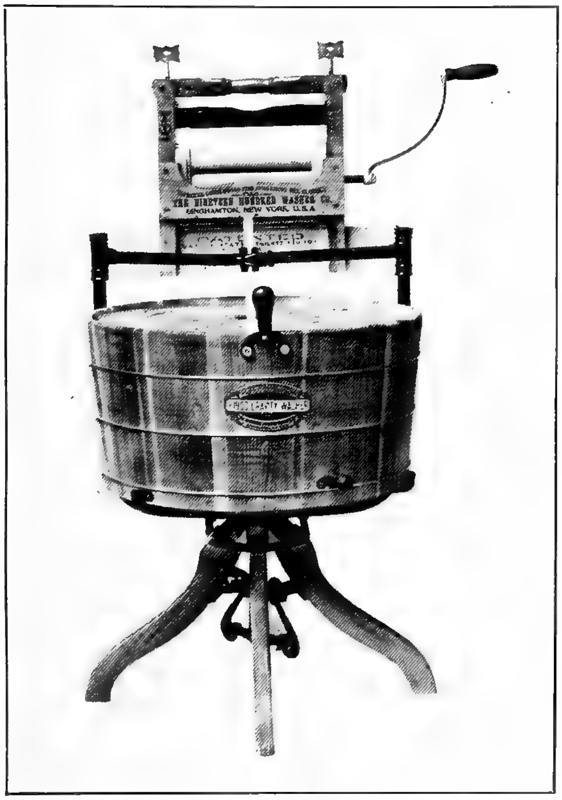
The 1900 Washer Company was incorporated in 1898 at Binghamton, N. Y., with the purchase of a patent on washing machines and a small factory in which to build the new device. Mr. A. A. Cassler, full of the project, went to a progressive young business man, Mr. T. B. Crary (who died in December, 1920), and found at once "the one man in a hundred thousand who was willing to take a chance on a new idea." It was then just a plain, simple, little machine to operate by hand; and introducing the novelty was hard work. But for the financial ability and business acumen of Mr. Crary, the young enterprise would have gone to the wall very quickly, for during the first five years scarcely 1,000 machines were sold. Then came a startling change in merchandising policy, predicated on a profound belief in human honesty and decency—and it won out! The proposition decided upon was to send a washing machine freight prepaid, without a cent of deposit, to any person in the United States, letting the recipients use the machine for 30 days. If they didn't like it, the machine could be returned at the company's expense. The trial would have cost nothing—and the episode would be closed. That extraordinary policy took nerve! It might even be said to be little short of genius. The company were told lugubriously that their losses would be so great that the scheme would thereafter be regarded as an infallible formula for the failure that spells bankruptcy. But it

THOMAS B. CRARY
Died December, 1920
Owner and Originator of "1900" Washer Co.

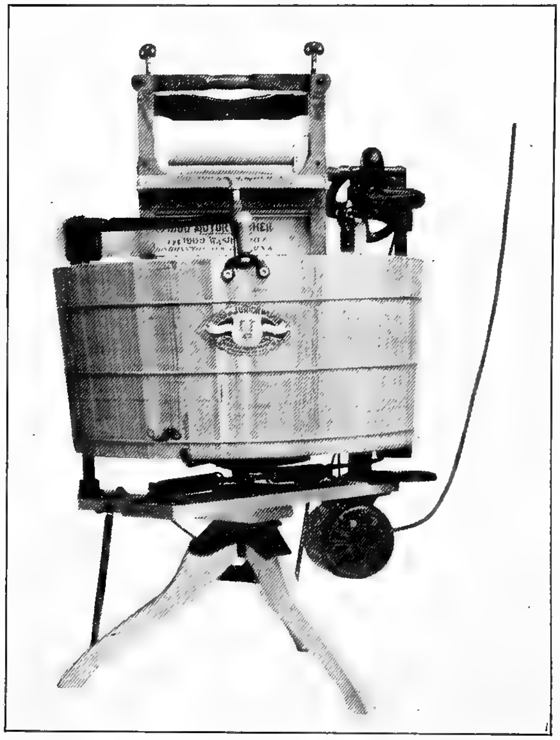
all turned out just the other way. The business swung at once into a big success and went on to a career of growth rarely

equalled in American industrial development. Experience proved that 98 per cent. of the people are honest, and that the company could afford to stand for the loss due to the careless, dishonest 2 per cent. in order to deal with the 98!

In the crucial year when this real Golden Rule was adopted, the company sold no fewer than 20,000 machines—twenty times its sales in the previous five years. And it is to be noted that, by shrewd advertising, the appeal was made direct to the "ultimate consumer." In the fourth year of this new régime, which assumes boldly that the great bulk of people with homes are naturally white and decent, the company ran up to a sale of 120,000 machines. At the present time, it is doing a business of $2,000,000 a year with enduring elements of maintained expansion. To say that there are many aspects to such a broad policy, with much incidental psychology, and a lot of commercial experience of an unusual character, would be to state the obvious. One does not sell by mail on such a credit basis, some 1,200,000 machines of any kind, in addition to opening up a novel market, without securing also a unique fund of valuable information.



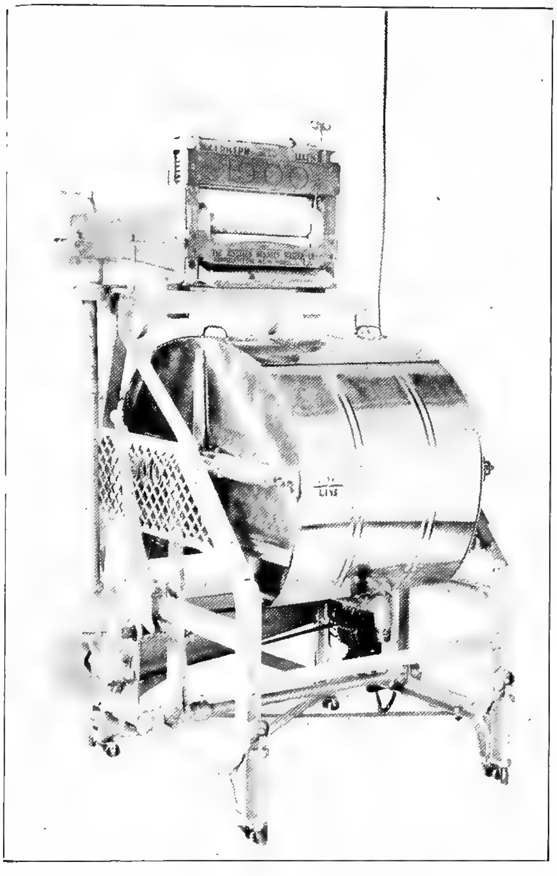
"1900" Gravity Washer



The First "1900" Electric Washer

Being evidently a highly progressive concern, the management aside from its peculiar convictions in regard to social ethics, was keen for improvements on the mechanical side of its industry. As a matter of fact the next step proposed was away from hand operation and it was planned to put a water power washer on the market. The initial intention of the company was to produce, and it did develop a machine to be run by city water power—ideal where the community has plenty of water under good pressure. The company employed expert mechanics and inventors to work along this line, and in 1903 had de-

veloped a very promising appliance, a waterpower washing machine operated by a simple reciprocating water motor. It looked good to the company—so good that they exhibited it at the St. Louis Exposition of 1904. Orders were received by the thousands, but the general experience derived at the Exposition brought the evidence that the innovation was not in reality up to the standard of the good old hand machine. So with characteristic energy and enterprise, the officers threw the machine into the discard of the scrap heap, and at once developed a third type to be operated by a water turbine motor. The first likeable machine of this type was sent



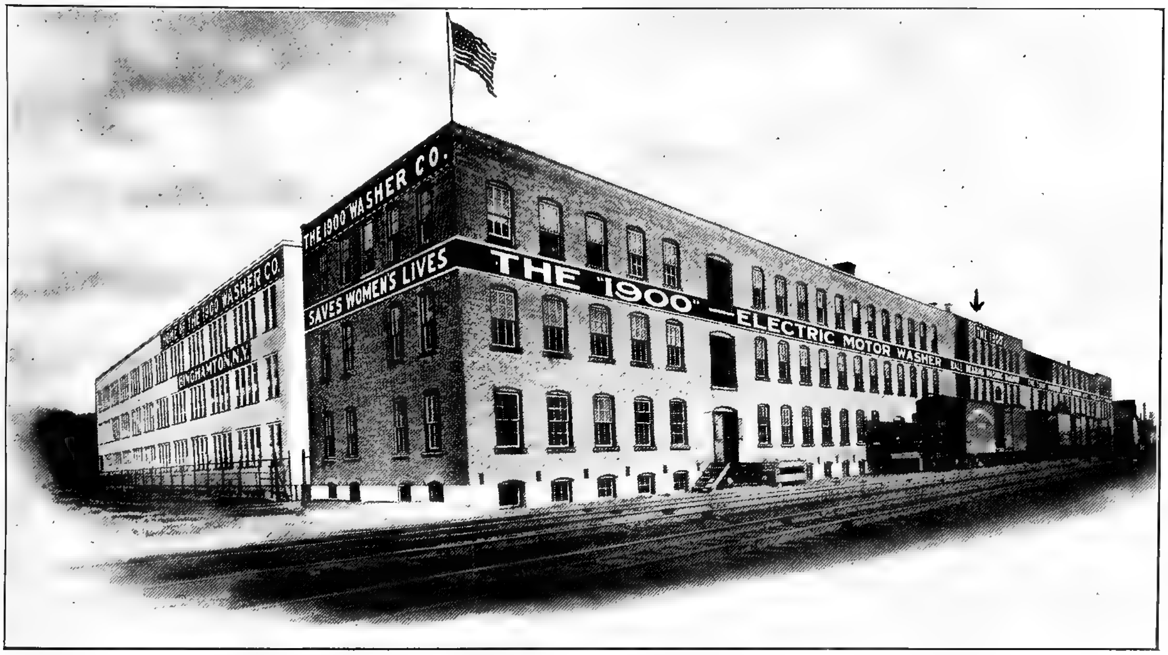
The "1900" Cataract Washer

to San Francisco, where it was promptly burned up in the terrible fire that followed the earthquake. Once more a change in policy arose out of a crisis. At the start, as has been noted, the washer was run by hand, and it was then sold in the country districts rather than in the city. Today the big field is for the more expensive electric machine; and after the little holocaust on the Pacific Coast, the officers turned swiftly to the lurking idea of operating their washer by electric motor. Some admirable and successful experiment work was done at once, and, shortly after, the electric was placed on the market on the same terms and conditions as had applied to the hand machine. It was a very fair success at once, but the company found that it was greatly handicapped by the fear that every one had in those earlier days of an electrical device by which they might accidentally be electrocuted. Through force of circumstances it thus became necessary finally to put the machines in the hands of the trade, which could deal directly with the timid housewife. This original electrical machine was so good and had been so well worked out that with a few minor improvements it was pushed as the company's leading machine until 1915, when it put on the market the well-known "1900" Cataract Electric Washer.

These machines cost ten times as much as the primitive hand machines, their forerunners, and are bought in all the large towns and cities; and while some conditions persisted, the newcomer could hardly be sold on the old-time long-range payment plan. Representatives or dealers were established or recognized in the great centers of population who buy direct from the manufacturer and resell to the local customer on their own terms. The mail order business, however, continues in large volume on the lower priced "Gravity" machines, and as general manager H. L. Barker, says: "That horse and the policy are just as good to-day as they were thirteen years ago when they pulled us up the hill."

The 1900 Cataract washer is the highest priced of all the machines which have a large volume of sales, and many of its features are quite interesting. The original machine was of wood, but experience showed that women wanted copper wash-boilers that lasted a lifetime; and the company found that it paid to bring out a machine in which the tub was made of

copper and the rest also of metal—virtually steel. Embodying in ideal mechanical manner the principle of double action oscillation, the machine subjects the clothes to complete and irresistible water agitation justable jacks so that it can be lifted off the castors, and can be leveled up to suit an inclined laundry floor. Moreover the operator does not have to stoop at her work in getting the clothes in or out of



Present Plant of "1900" Washer Co., Binghamton, N. Y. Arrow Marks the Original Building

so necessary for quick and perfect work, without wear or tear of the garment. The tub is made of copper, tin planished, resisting all chemical action of soapy, greasy water, and the equable application of the motive power on each side of the tub through steel driving arms, removes all strain from the tub itself. The "Cataract" has a banded steel frame, and ad-

the "Cataract," which has the largest opening of any oscillating machine, besides being of largest capacity. Adaptation to electric power is one essential thing, but it has required equal ingenuity to introduce the many other refinements which justify the producers in saying of it: "We rank the electric washing machine as one of the greatest inventions of the day."

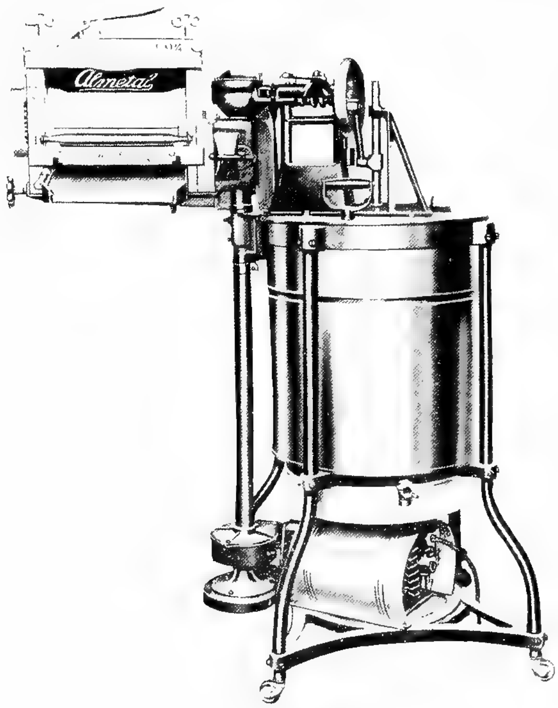
ALMETAL MANUFACTURING COMPANY

To the Almetal Manufacturing Company of St. Louis, Mo., belongs the credit for the first washing machine with "heat applied." The Almetal household steam laundry made by the company is not only

The First "Heat Applied" Machine Made by the Almetal Manufacturing Co.

electric-operated, but underneath the copper boiler or tub is a burner, either gas or electric, which heats the water right in the machine and keeps the water hot while the washing is in progress. This burner also enables the housewife to boil her clothes in the same machine and steam and sterilize them. This machine also lifts the clothes out of the hot water, and has an electric-operated wringer.

The first "heat-applied" washing machine, brought out by the Almetal Manufacturing Company, consisted of a specially-designed cast-iron furnace, easily and quickly converted into a laundry stove. On top of this was placed a boiler fitted with a washing apparatus operated by hand lever. Thousands of these hand-operated machines were sold throughout the Southwest, and crude though this device may have been, it demonstrated the soundness of the idea of a "heat-applied" washing machine. It was, therefore, but a succession of steps to the development of the present type, an electric-operated washing machine with heat applied. The Almetal Manufacturing Company now market these machines, both electric-heated and gas heated, in immense quantities. On this page will be found a small illustration of the first machine ever made with "heat applied," coal or wood-heated. There is also illustrated the modern "Everhot, Almetal Washer," now made and sold by the Almetal Manufacturing



The Modern "Everhot, Almetal Washer"

Company, electric operated and electric heated, or electric operated and gas heated, as may be desired.

History, therefore, records that the Almetal Manufacturing Company not only conceived this fundamentally new idea in laundry machines, but developed it to its present state.

HAAG BROTHERS

HAAG BROS. COMPANY, PEORIA, ILL.

George A., and Albert R. Haag, owners of the firm Haag Bros. Co., are twin brothers, born in Rock Falls, Ill., March 30, 1879. They received their early education at a Rock Falls grammar school, but while they were still young their father died, and the entire support of the large family fell upon the shoulders of their mother. They were thus compelled to leave school before completion of their education, to assist her.

They worked in Rock Falls for a time then went to Peoria, Ill., to find bigger and better work. For 12 years they followed the blacksmith trade; and both brothers, being of an inventive turn of mind, were continually devising new methods or ways of doing things to attain better results, and save time.

The hard work undergone by their mother had left in them a firm determination that they would some day invent something to minimize the drudgery of housework. Of just what nature this relief would be they had not decided until about 1910 they surmised that a power washing machine would find great favor among housewives.

With this thought in mind they started on their first power washing machine, operated by means of a gasoline engine or tractor power. By putting in all their evenings and spare time, the machine was finally completed, and the results were very encouraging. Work was immediately started on a second machine, with improvements over the first.

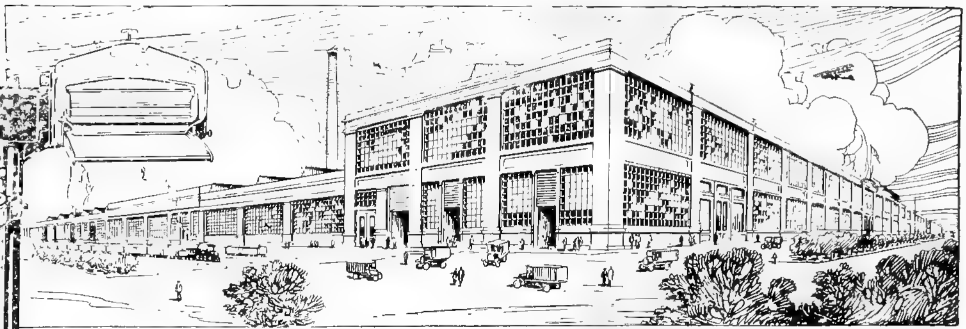
In 1912 they decided that they could accomplish greater results than their regular trade offered by putting their entire time into the manufacture of power washing machines, and so a small corner of the building at 812-16 No. Commercial St., Peoria, Ill., then occupied by the Western Stove Works, was rented, and work in the washing machine field began in earnest.

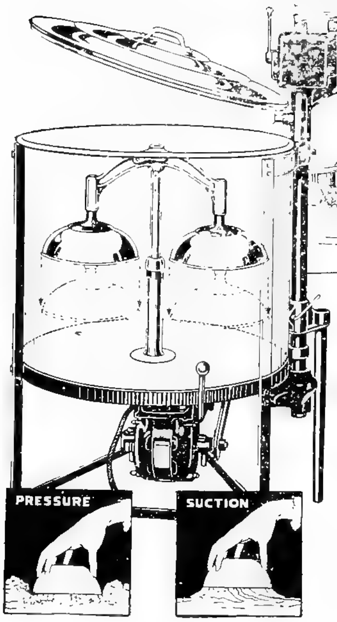
It was later realized that much greater work might be accomplished if they could make a washer with a small electric motor attached. Previously the majority of their machines were sold for farm use, and they now wanted one that could also assist the city housewife.

With this intention they redirected their efforts and before long had a machine equipped with a motor. This machine was placed before the public, and they were soon swamped with orders. This meant that larger quarters were needed and some additional help must be employed. Their growth since that time has been remarkable. They succeeded in securing the entire main floor of the building occupied, but even that was soon too small. The whole two-story building was taken over, and more employees were added to their steadily increasing force. By this time their machines were becoming very popular throughout the entire country. Early in 1918 they foresaw that their quarters would not long be adequate to meet the demands, and in the spring of 1919, they purchased a site in East Peoria, on which now stands a magnificent $200,000 building, bearing their name, the realization of their dreams.

They, however, have made provisions for a still greater future and purchased considerable land surrounding the present factory, and have had the building so arranged that extension and addition can be easily accomplished. Shade trees were planted along the frontage and a beautiful lawn with flower gardens and shrubbery artistically placed, pleases the eye, and attracts the admiring attention of the steady streams of passers-by. The building itself is indeed a remarkable example of modern factory construction.

THE SYRACUSE WASHING MACHINE CORPORATION





The fundamental theory on which all washing machines for household use are built, is the agitation of a soapy, alkaline solution in and about and around and through the fibres of the garments being washed.

Dirt does not collect on the fibres of garments, but it does collect in the mesh of the garment material. The necessary agitation to clean the clothes is obtained by four fundamental types of washing machines for household use, and in their order of development these four types are: The Vacuum type; the Dolly type; the Cylinder type; and the Oscillating or Rocker type.

THE VACUUM TYPE

The vacuum type, or the vacuum method which cleans clothes by air pressure and suction, was the first method developed to clean clothes other than by the ancient process of rubbing over flat stones or a corrugated surface. To the detriment of all washable apparel the process still survives.

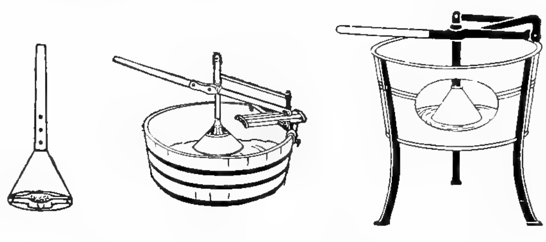
The vacuum type machine, of which the "Easy Vacuum" is held to be the best sample, has gone through a process of development since about 1875. The "Easy Vacuum" in its present stage of development is the evolution of the vacuum type machine as worked out during the period from about 1878 up to the present time.

Experience has shown that the vacuum type machine, cleaning clothes by air pressure and suction does its work most efficiently when the cups operate through the bottom of the tank. This one may test out at any time by comparing the washing efficiently of any vacuum type machine, the cups of which operate through the top, against the washing efficiency of the "Easy Vacuum."

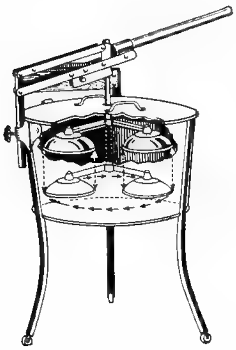
The vacuum machine as made by the Syracuse, N. Y., Washing Machine Corporation may be driven either by hand-power, gasoline power or electricity.

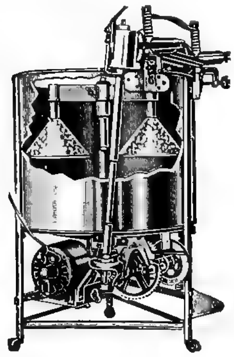
RAILROAD FACILITIES

The "Easy Vacuum" electric washing machine is now being made in the most modern washing machine plant. The buildings are situated on twenty-five acres

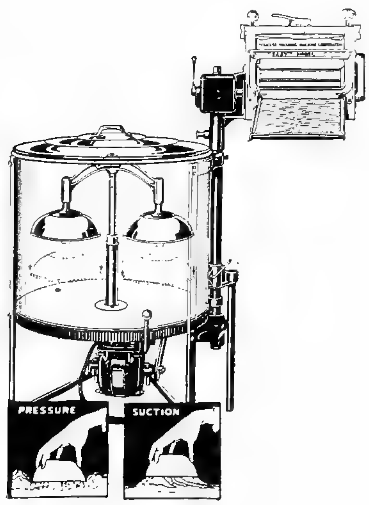


Early Types of the Vacuum Washer





of land, served by the Lackawanna Railroad with double switch capable of holding twenty cars, adjoining the New York Central and Barge Canal Terminal, the latter giving access to ports on the Atlantic Ocean and the Great Lakes. The manufacturing building is 510 feet long by 300 feet wide; all one story, saw-tooth roof construction, excepting that portion which is occupied by the administration offices, assembly hall, cafeteria, experimental department, museum and drafting room. The plant is equipped with brand new, mod-



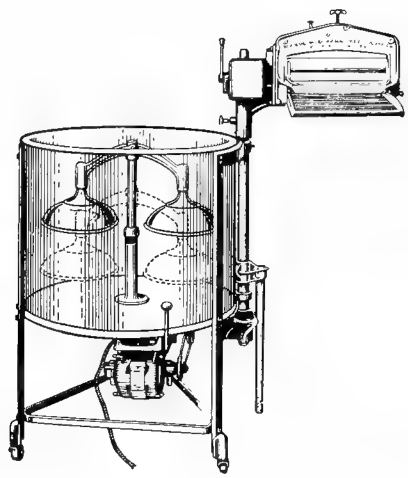
ern high speed, quantity production machinery, capable of producing 1,000 "Easy Vacuum" machines per day when operated at maximum production. Production is carried on under the progressive system, viz.: the raw materials entering at one end of the plant, and continuously moving through its various processes of production and final assembly until the finished machines reach the crating and shipping department.

THE BUILDING AND PRODUCTION CAPACITY

The plant is absolutely fire-proof, complying with all the rules, regulations and requirements of the State Labor and Fire Underwriters' laws, etc., which secures the lowest cost insurance rates. These fire insurance rates also influence the premium or cost of the profit and loss and use and occupancy insurance in the event of a shut-down due to a fire.

OWNERSHIP

The Syracuse Washing Machine Corporation is the result of the continuing life of a washing machine business which has been in Syracuse since about 1878. Undoubtedly it is the oldest washing machine corporation in the United States. It now has from $3,000,000 to $4,000,000 invested in the washing machine business. The controlling stock owner of this business is President of the Corporation, Mr.



J. N. Derschug. The minority stockholders in the Corporation are Ford, Bacon & Davis, 115 Broadway, New York City, a well-known organization of engineers which has done engineering work for almost every large public utility corporation in the United States.

THE KELVINATOR CORPORATION, DETROIT, MICH.

Refrigeration without ice—in your own home— frigid food and drink in the hottest weather without frozen water, either natural or artificial—an automatic cold storage plant (fool-proof) in your own icebox—these are not dreams but realities.

The Kelvinator Corporation of Detroit has answered the demand for automatic domestic refrigeration. It has brought a veritable wonder to the home, via the electric route, for the same socket which furnishes light and heat, can and will now furnish cold, cheaply, efficiently, and automatically.

Mechanical refrigeration has been a successful accomplished fact since 1838, the original machines having been run by steam. All have seen this refrigeration for years in the largest and best meat markets, and have known of it in the packing and cold storage industries. Such plants, however, were then, and are still, very costly, and highly technical; and being run with anhydrous ammonia, requiring very heavy pressure, they need a trained engineer continuously on the job.

It was self-evident that if such a small refrigerating plant could be manufactured for domestic use, an appliance of great economic worth, as well as of great commercial possibilities, would be brought into being. The question was, How?

In September, 1914, Mr. E. J. Copeland, and Mr. A. H. Goss, both of Detroit, set out to find out how. Under the name of the Electro-Automatic Refrigerating Company, they perfected their initial organization. Mr. Copeland served as its president, and Mr. Goss, as its vice-president. This company was conducted as a private experimental enterprise, and was formed simply to give business form to a rudimentary organization whose sole object in life was to answer that puzzling question of "How?"

Roughly, here were the obstacles in the path. The only assured success among the known refrigerants was anhydrous ammonia. This requires very heavy pressure to condense it, after it has expanded and furnished its refrigeration, which, of course, means heavy machinery, large consumption of power, etc. Then too, such a plant is expensive to build. It was felt that, above all, a successful domestic plant must be within the reach of the majority in price. There were other obstacles, such as the fact that many States require a trained engineer on the job with an ammonia plant, and the fact that ammonia is a suffocation gas of great pungency.

In spite of these facts, the first attempt was with an ammonia machine, and an experimental model was produced; but try as they would, they could not get away from the very nature of ammonia, which made it unsuitable for household use. Hence this unit was soon discarded.

The next attempt was with air. The air was first compressed, and then discharged into a tank placed in the ice compartment, and refrigeration resulted from its expansion. Inasmuch as a great volume of air was necessary to bring about a given quantity of refrigeration, the power requirements of this unit were found impractical, and the air compressor was abandoned, although it filled the need for household use, ideally, so far as the refrigerant itself went.

Then followed, for a year, a series of expensive and disheartening experiments. Finally in their search for a proper refrigerant, they decided upon Sulphur Di-

oxide, a refrigerant, liquid under pressure, but gaseous in its normal state. This is non-poisonous, non-inflammable, and non-explosive. It is used hygienically as a disinfectant, and its worst drawback is that it is a nose and throat irritant.

They had such encouraging results with this refrigerant, that in the spring of 1916 they completed their first Sulphur Dioxide machine. After repeated tests, and repeated successes, they realized that at last they had a triumph. The next question was the name. Rightfully enough they named it after Lord Kelvin, the great Scotch physicist to whose work with temperatures, the world of science is so profoundly indebted. They then reorganized as the Kelvinator Corporation.

After a year and a half more of experiment and improvement, the first installation was made in a private residence. This was naturally very carefully watched, and two troubles developed, namely, a leakage of the gas, which is very volatile, past the crank shaft bearings, and a weakness in the automatic control. The first trouble was absolutely eliminated by the introduction of a self-lubricating, self-aligning, metal seal; and the second, by improving the sensitiveness of the thermostat used, until it held the range of the temperatures within four degrees.

A Kelvinator-Equipped Refrigerator

It was realized by the officers of the Company that, to be practical in the average household, the machine must be automatic, fool-proof, long-wearing, simple, noiseless, and inexpensive. Every effort was laid along these lines, and finally, in February of 1918, the perfected machine was brought on the market and a sales office opened in Detroit.

From that time to the present, so careful was the original experimentation, and so expert the production, no radical changes have been found necessary. Minor refinements of course have been made, and will still be made, as found expedient, but in all its essentials, the machine today is the machine brought on the market in 1918. The public was not asked to buy an experiment.

And now for a brief description of the machine. The refrigerating element, the only part of the machine which one sees every day, consists of a copper tank placed in the ordinary ice compartment, shaped like a block of ice, and of the largest size that will go in the compartment, and still give room around it for air circulation. This tank has inside it the copper coils in which the sulphur dioxide expands, and is also filled with brine, which steadies down the changes in temperature, and furnishes a reserve of refrigeration. On top of this tank are set the expansion valve, through which the sulphur dioxide passes, from a liquid under pressure on one side, to an expanding gas on the other; and the thermostat, which automatically closes or opens the switch as the temperature in the box varies by a maximum of four degrees.

Down cellar, or in some other out-of-the-way place are the compressor, condensor and a quarter-horse-power motor. The condensor is a coil of copper pipe, wound in rectangular shape, mounted on a base, and enclosing the motor and compressor. The compressor is a two-cylinder reciprocating type.

To most persons, the subject of refrigeration is a deep mystery, and yet it is very simple. It may not be amiss to describe in a few words, just how Kelvinator does its work. Heat is a form of energy, and thus cannot be destroyed or changed. It can only be transferred from one body to another. This flow of heat, when two bodies of different temperatures are brought together, is always from the higher temperatured body, to the lower. Thus, if one puts a kettle of water on the fire, the heat units flow out of the fire into the water. The water is raised to 212 degrees, and remains at that temperature (at sea level pressure, 16 lbs. to the square inch) until it all boils away. The water could not boil if it did not absorb heat from the fire.

In exactly the same fashion, sulphur dioxide could not boil, if it did not absorb heat from some outside source, higher in temperature than itself. The reason that sulphur dioxide is a refrigerant is that it boils at 14 degrees (sea level pressure). Thus it continues to boil as long as it is touching anything higher than 14 degrees in temperature. It is clear therefore, that if Kelvinator kept pumping sulphur di-oxide into the refrigerator, it would bring the temperature in the box down to 14 degrees. As this would freeze and spoil food, the thermostat stops it before it reaches that point.

As a matter of fact, the refrigeration could be furnished without machinery of any kind, simply by putting sulphur dioxide into the refrigerator as needed, and exhausting the vapor or gas, resulting from the boiling into the open air. This would be expensive, however, and it is where the machinery steps in to do its part.

The gas is led from the pipes, in which it expands and boils, back to the compressor, which, operated by the electric motor, pumps a pressure on it, exactly as we pump a pressure on an automobile tire with air. The boiling point of any liquid depends entirely on the amount of pressure. At 16 lbs. to the square inch, water boils at 212 degrees. In a vacuum, water boils at 32 degrees. The higher the pressure, the higher the boiling point. The condensing point (the degree of temperature at which a vapor will change back to a liquid) is always the same at the boiling point.

Thus when a pressure is pumped on the sulphur dioxide, its boiling point and consequently its condensing point are raised.

At 50 lbs. it condenses at 85 degrees. At 60 lbs. it condenses at 93 degrees. Thus if the pressure is raised to 50 lbs., and the temperature of the air surrounding the condensor coils is 85 degrees, the sulphur dioxide gas will condense back to a liquid, whereupon it is sent back up to the refrigerator, again to expand to atmospheric pressure and boil at 14 degrees. This completes the cycle.

The actual cold produced in the ice-box by ice, is produced by the circulation of the air in the box striking against the surface of the ice, and the heat units flowing out of the air and into the ice. As the melting point of ice is 33 degrees, it is self-evident that the coldest the box can ever get at its coldest point is 33 degrees. The number of square inches of ice surface presented to the air controls the amount of this 33 degree temperature that can be furnished. Thus the first minute after a new block of ice is put in, the amount of refrigeration furnished starts to decrease, and decreases constantly as the ice melts. The melting of course presents a constantly wet surface to the air and thus fills the air with moisture. This is what molds and rots food.

Kelvinator, on the other hand, puts into the ice compartment, a copper tank, as large as the largest block of ice that can be put in. The surface of this is 22 degrees, 11 degrees colder than the coldest ice—and it never melts. Thus the refrigeration furnished by Kelvinator is always 11 degrees colder than the coldest one can ever get in the box with ice; and because the brine tank stays the same size, its average is 18 to 20 degrees colder.

Because it is at 22 degrees, 10 degrees below the freezing point of water, it freezes the atmospheric moisture to the sides of the tank, in the form of frost. Because it is the moisture in the air which carries the odors and impurities, the effect is that Kelvinator automatically launders and dries all the air in the box, rendering it absolutely dry and clean.

The result of this clean, dry, non-fluctuating cold on the food is amazing. A typical demonstration is to have butter, cheese, and onions on the same plate. There is, and can be, no taint in the butter. Ripe tomatoes have been kept six weeks; milk has been kept sweet fourteen days; butter has been kept fresh five months, oranges and grapefruit have been preserved six months, and eggs a year and seven months. One family went away from home for an automobile trip of three weeks, leaving the food in the ice box just as it was. On their return, they prepared supper with the food left in the box.

But Kelvinator does more than keep the food perfectly, for it freezes dainty blocks of ice out of the finest spring water for table use. Many uses are made of these blocks. Maraschino cherries, violets, and sprigs of mint are frozen in them. Gold initials for guests of honor, and place cards, gold numerals for birthday parties, etc., are not unusual; and of course, tinting and flavoring the ice blocks is common. Mousses, sherberts, and ices may be frozen in the ice trays, without the labor common to the ice cream freezer, as may also frozen puddings and custards.

And best of all, Kelvinator is not expensive to operate. The operating cost in any one city, depends of course on the cost of current, and also on the size of the ice box, etc., but an average figure struck from hundreds of installations is $2.50 per month. The mechanical attention on the part of the house-keeper is practically nil, and the average machine does not need attention from the service station more than once a year.

The Kelvinator Corporation, believing that it can only exist as it renders service, has adopted the strong policy of making installations only where it can furnish service, and its only breaking of this rule is in installations aboard private yachts, and on U. S. Government ships.

Because of this sound adherence to this rule of service, the writer can close this article in no better way than by reprinting here the Kelvinator man's creed.

"To so conduct myself each day, that at its close,
I may truthfully say—
To my customer for whom I have worked,
To my Company under whom I do my work,
To my product which made my work possible,
To those dependent upon me and on my work,
And to myself,
This day I have given all that is in me,
This day I have rendered perfect service.
That is my creed."

STANDARD ELECTRIC STOVE COMPANY

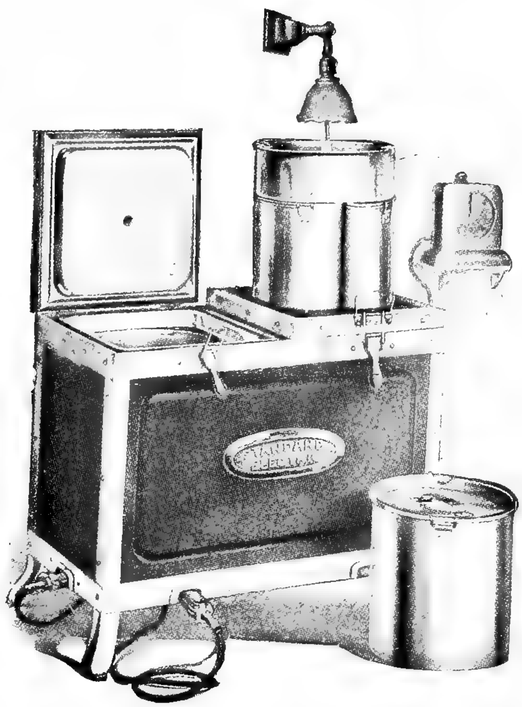
TOLEDO, OHIO

It will probably startle a good many people to know that one new electrical art and industry grew during the period 1914–21, when all the nations of the earth were devoting their energies to appliances and methods of destruction. Prior to 1914, the electric stove or range was practically unknown, but from 1917 to 1921 inclusive the American output was about 570,000, and it is believed that the high production of 1920, namely 195,000, has been recently surpassed. Half a million electric ranges in actual use in the homes and institutions of the United States would seem to be a moderate statement of the situation in 1922. Electricity has known many "booms" as it has successively invaded new fields of public service, but certainly none has surpassed the conquest made by the appliances that utilize current in an infinite variety of culinary purposes. The reasons are not far to seek. Gas has many arguments urged in its favor, but in some localities, especially in the West, and where there is no natural gas left, electric ranges are much the cheaper to operate. Moreover, they are "quicker on the trigger," hold the heat better, do not heat up the kitchen in summer, are much more sanitary and cleanly, with absence of dust, soot and smoke, and can be depended on for uniformity alike in operation and in applying the heat to the raw food of whatever kind. Blackened pots and pans belong to the dark ages before electricity. A vital economic advantage is that electrically cooked meats lose less by weight in the process, are sweeter and juicier, and are appetizingly browned.

The first American patent on an electric range was granted to George B. Simpson, of Washington, D. C., on Sept. 20, 1859, being for an electric heating element that was practically the same as the open heater of the present day. But like so many other nascent electric arts, development in this field had to await the coming of an inexhaustible, universal supply of current from the dynamo; and then the electrical energy thus rendered available had to be made so cheaply that it could compete on more than even terms with all the older agencies, with some of which women had been familiar ever since the use of fire marked the dawn of civilization. But even when the central station had been established as a public utility, thanks to the genius of such men as Brush, Edison, Elihu Thomson, William Stanley and others, more than a quarter of a century had to elapse before the distribution circuits had become so multiplied that the service limited to streets, offices and factories could be carried into the home. The process was evolutional rather than spectacular, and took time, for both physical and financial reasons. Many praiseworthy attempts were made by inventors to meet the opportunity that could be seen looming up ahead, but it may safely be asserted that the commercially practical range does not date back further than 1910. An Englishman named Downing gave a suggestive exhibition of electric cooking appliances at the Crystal Palace, Sydenham, in 1891, and in America Mr. W. S. Hadaway around 1895 described and produced appliances leading up to his patents of 1896–7. About that time, Andrew Carnegie installed one of these pioneer electric ranges in his famous Fifth

Avenue residence, but that very fact established the point that electric ranges were limited in those days to the millionaire class. Today, it is a very modest home that cannot afford an up-to-date electric range. In fact, the proposition may be inverted, and it can be asserted that in these days of costly food and expensive domestic help, no home can afford to be without such efficient, economical apparatus as that made by the Standard Electric Stove Company of Toledo, Ohio. It is indicative of the brighter, better times ahead for the American household, that so much of immediate central station effort is being directed to the domestication of electricity. In its exhibits of 1909 and 1910, the National Electric Light Association welcomed, as unfamiliar newcomers, the crude electric ranges then put forward, and looked at them rather dubiously. Today the thoughts and ambitions of its Commercial Section and members are strenuously bent on the expansion and occupancy of the vast new business field that the range typifies.

Only the catalogues and trade literature of the Standard Electric Stove Company, with an inspection of its numerous appliances and devices, can give an adequate idea of the skill and ingenuity that has been concentrated on the production of their splendid apparatus. A very brief summary only can be made here of some of the salient features that have won popular approval and widespread adoption. The Standard No. 601 range, for example, will cook six foods at one time, being equivalent to a 6-burner gas range. In each cooking compartment two foods can be cooked at the same time over a single 660-watt "element." The Standard is niggardly economical of space, a great desideratum in kitchens, where there is never any room to spare. All the cooking compartments are in one line; no hot-plates are located back of each other, barring the way. Easy to handle on top, the Standard is equally easy to clean under and get around. It has, moreover, a cabinet type oven with full glass front, just high enough from the floor to meet the direct vision of the user. The appearance in the kitchen is most agreeable and substantial. The construction is double-wall, heavily insulated with rockwool to retain heat. All the inner walls are of rustless, heavy gauge sheet aluminum. The outer walls are of Armco rust-resisting iron, 22-gauge, finished handsomely in royal blue and velvet black or white, enameled inside and out. "Ever-Wear" aluminum utensils are used, as in the heat-retaining oven and cookers. The optional use is provided for of an automatic clock regulator in the various types,



A Standard Electric Cooker Which Operates on 40 Watts

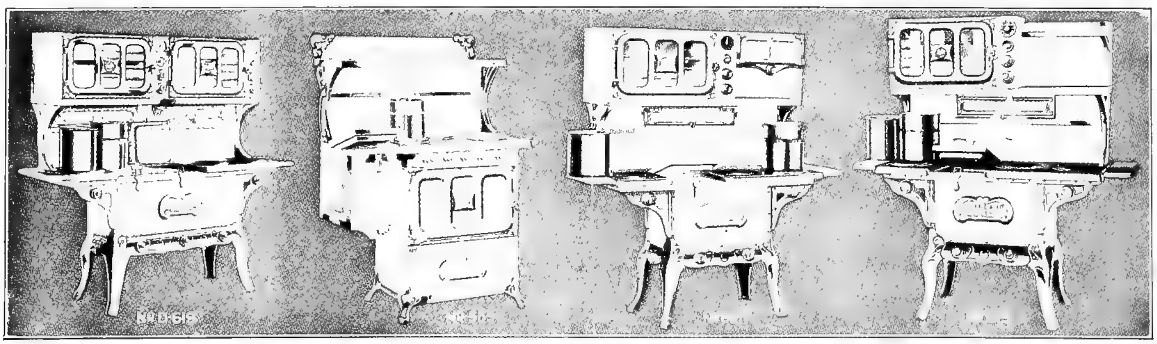
much more reliable than the ordinary cook or kitchen maid. Combining a four-point switch with a high-grade, rugged clock movement, and placed in full view, the regulator enables the heat to be both measured and controlled, economically prevents use of excess current, and responds conveniently to each requirement of the user, as the cooking tasks vary. The connections are made for two- and three-wire systems, on a solid porcelain binding block in the main fuse box, readily accessible through the front fuse box door, all plainly indicated; and all the wiring is in conformity with official requirements.

Every range of the cabinet type is fitted with a lamp outlet connection from which any lamp-socket device can be operated. A lamp in this outlet lights up the whole top of the range and the interiors of the compartments. All ovens have racks and broiling pan. The electric cooker in all Standard ranges can be operated on 40 watts, which will maintain even heat with the cooker switch set at "low."

Hotplates of the Standard type are of cast iron polished on the upper side, 8½ inches in diameter. The Nichrome resister is cut and shaped to the desired wattage, and then coiled and laid in a special clay product, which combines the qualities of being a highest degree heat conductor with absolute non-electric conduction. As with porcelains, it can be baked to a glass finish, in a furnace, at 1500°. The cement practically amalgamates with the polished iron hotplate in which it is baked, and when reversed is the upper side of the disc on which short-time cooking is done quickly. A range of from 40 to 3000 watts is available with these hotplates, at any voltage. To obstruct the usual downward radiation, the Standard stoves employ a reinforcement pad of rock mineral wool cupped in a rim bowl, with a porcelain terminal block, to which leads are attached. The inverted bowl prevents heat dissipation into the range top and frame. After current is cut off, the stored heat in the Standard hotplates performs slow cooking for some time. A variation of the hotplate is afforded in the Standard "open coil" burners, either of the hotplate type, in which the unit has an open framework with insulated bottom; or the oven burner, in which the upper section is used for broiling evenly without risk of fire and the lower burner is installed flush in the recessed bottom of the oven and is covered with a baffle plate.

There are many refinements in the Standard ranges and auxiliaries. For instance, the ovens are all provided with a vent. If steam cannot escape it renders food soggy, hence an "air-tight, steam-tight" oven is undesirable and impractical. Surfaces and crusts will not brown with superfluous moisture around, and wasted current must be used to get rid of the steam if it is not released. The glass front is also a notable "stunt." It enables the operator to watch progress without opening the door, as must be done frequently if such direct inspection is not possible, with a loss of 15 degrees of heat in 15 seconds. Another item of convenience and efficiency is that a reliable oven thermometer is fitted into the heat-treated glass front of every Standard range.

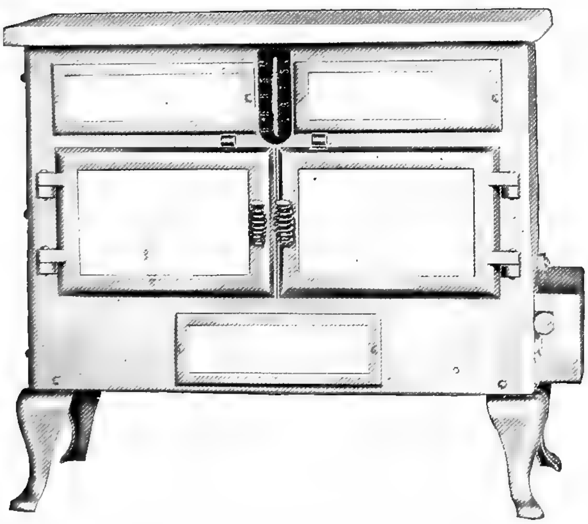
The Standard Electric Stove Co. of Toledo, Ohio, with its capital of $300,000 and its reputation for carrying out its contracts, wants every purchaser of its products to feel perfectly safe in buying one of its models. Its policy is to stand behind a strong guarantee, and dealers handling the Standard brand do not hesitate to extend the same assurance to their customers.



A Group of Representative Products of the Standard Electric Stove Company

H. G. WEEKS MANUFACTURING COMPANY

The H. G. Weeks Mfg. Co. was founded in 1915 at Hamilton, Ohio, by Harry G. Weeks, E.E. for the purpose of manufacturing electrically heated appliances and specialties of the highest quality. Harry G. Weeks, the founder, graduated from Syracuse University; became assistant to Mr. W. S. Andrews, Consulting Engineer for the General Electric Company at Schenectady and assisted Mr. Andrews in the pioneer work on electric heating appliances; later was assistant to Mr. William Stanley at the Stanley plant at Pittsfield, furthering development of electric heating appliances. Mr. Weeks served 6 years with the General Electric



The Automatic Sterilizer

Company as electric heating engineer. In 1910 he opened offices in Chicago as consulting engineer, specializing on electric heating. During these years, Mr. Weeks brought out several hundred new electric heated appliances.

The first efforts of the H. G. Weeks Company were directed to an automatic sterilizer for use at soda fountains for providing sterilized glasses. The Government and many State Boards of Health have since adopted laws requiring sterilization, and their use especially in the South is quite general. The sterilizers for doctors and dentists were next marketed. The Weeks' Automatic Hot Air Sterilizers are recognized as decidedly superior.

With a conviction that electric cookery should be in every home, Mr. Weeks with an experience of seventeen years of experimental work and with a belief that there were four obstacles which prevented the universal use of electric ranges, which must be overcome before electric cookery could become general, spent two years in the laboratory endeavoring to raise the efficiency of the electric burner so that it would compete both in cost of operation and speed with fuel burners.

In September, 1920, this new burner was put on the market by the H. G. Weeks Mfg. Co. as an exclusive feature of the Weeks' ranges. The discovery was tantamount in importance to that of the tungsten lamp. The efficiency of an electric heating burner was raised from about 50 per cent to about 80 per cent.

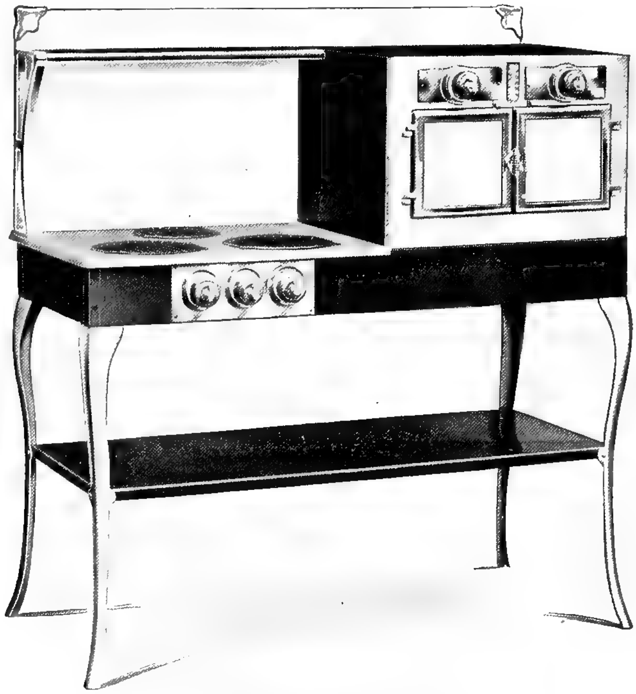
Burners heretofore have been either of the open type (heating by radiation) or closed type (heating by conduction). Mr. Weeks calls his burner the Radioductor burner because it is a combination open and closed type unit, heating by both radiation and conduction and using a new fabricated insulating block instead of refractory material, which forces 85 per cent. of the heat into the vessel.

The discovery means that the burners need not consume over 800 watts to do the

same work and in the same time as 1,200 watt burners of other designs. It makes it possible to make two-hole hot plates for lighting circuits where it has only been possible heretofore to get one. It has made it possible to make lamp socket ranges; it has cut the cost of cooking about half; it has reduced the maximum wattage of ranges nearly a half, allowing the central station to take care of twice as many range customers; also cutting the overhead capital investment per customer. It has made it possible to heat ovens as quickly as with fuel and at comparatively low watt input.

The discovery will go a long way toward making electric cookery general in use, and all that remains is an educational campaign to prove to the housewives the practical ability and advantages of electric cookery.

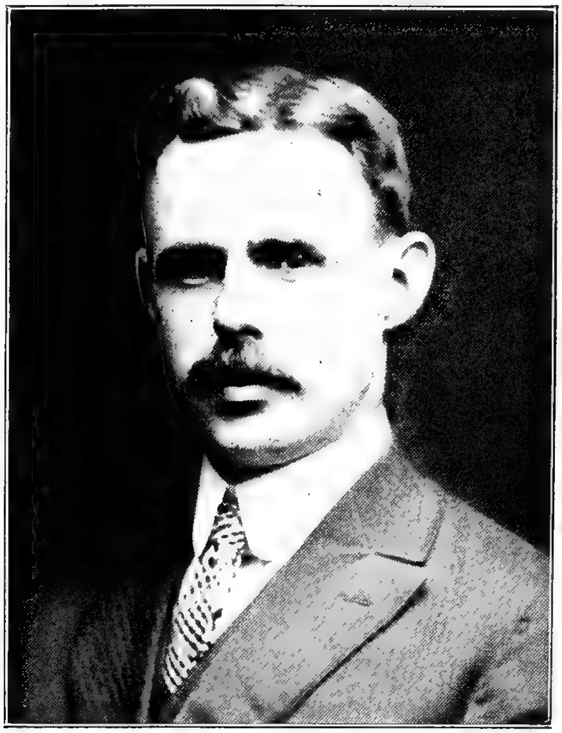
H. G. Weeks Mfg. Co. of Hamilton, Ohio, have 28 models of cookerettes and ranges; from a small lamp socket range to a four oven six burner range. These are made of cast iron, finished in satin nickel with buffed nickel trimmings, with onyx panels, mercury thermometer, zinc plated linings, heavily insulated walls, and six step oven control for all three heat burners.



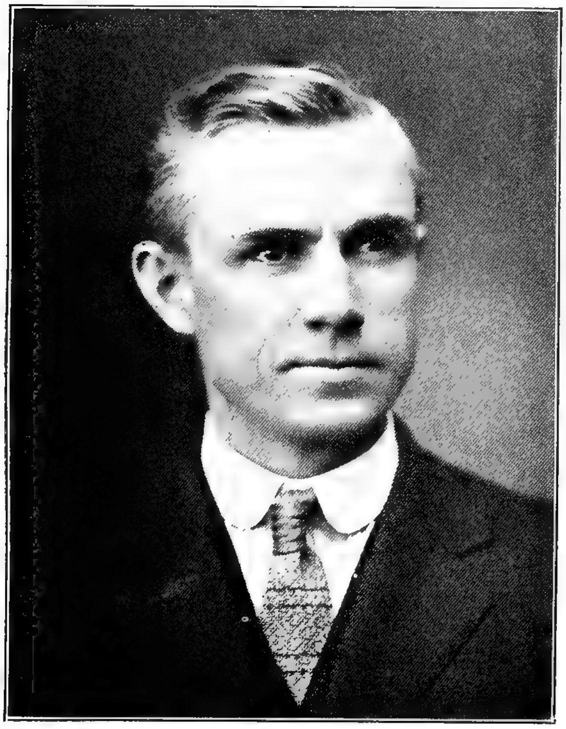
Typical Weeks Range

WALKER BROTHERS

Willard R. Walker, the originator of the Walker Dishwasher learned in early youth the trade of wood and metal patternmaking. Eventually he formed a company which also included three of his brothers. One of these was Forrest A. Walker, who was also an expert wood and metal patternmaker. The company, which was known as Walker Brothers Company, at first made only wood patterns —a little later metal patterns were added —after that tool, machine and die work was taken on. Their organization developed to successful commercial practicality many and various inventions and ideas of other people. In this manner they rapidly accumulated a fund of experience along these lines.



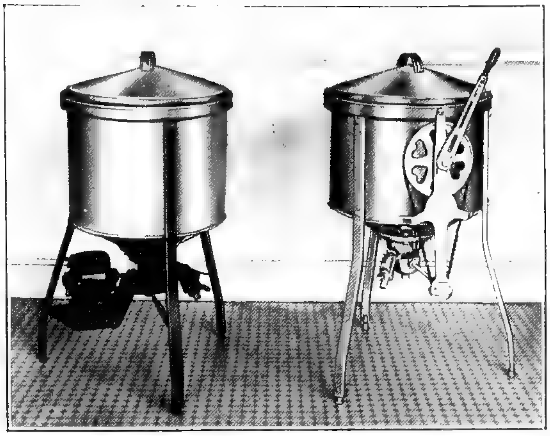
FORREST A. WALKER



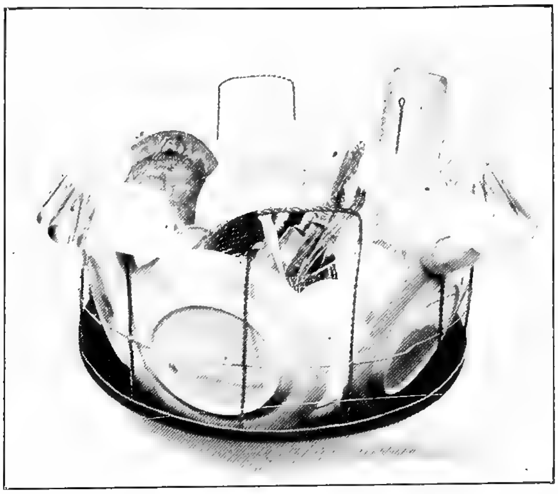
WILLARD R. WALKER

As far back as 1896 W. R. Walker first began to think about a machine for washing dishes in the home. At odd times his ideas were further and further developed, until about 1909 definite and energetic attention was given the matter. The

The Original Walker Hand-Power Dishwasher



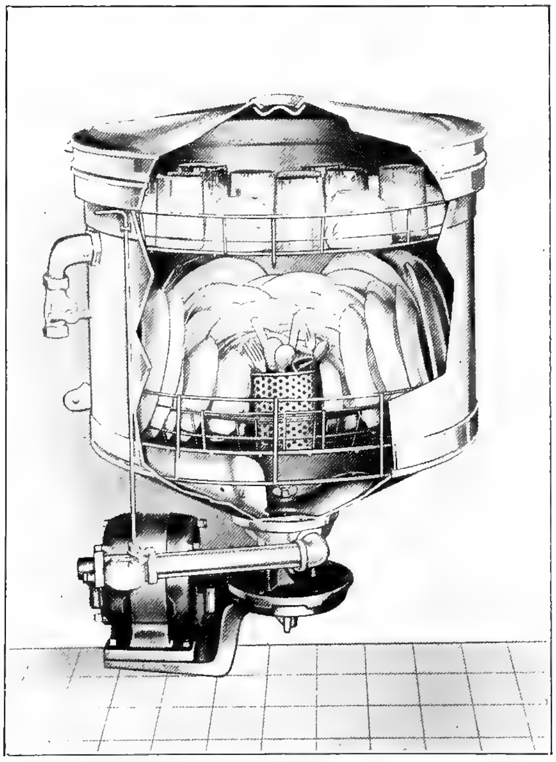
The Second Models—Electric and Hand Power—Walker Dishwashers



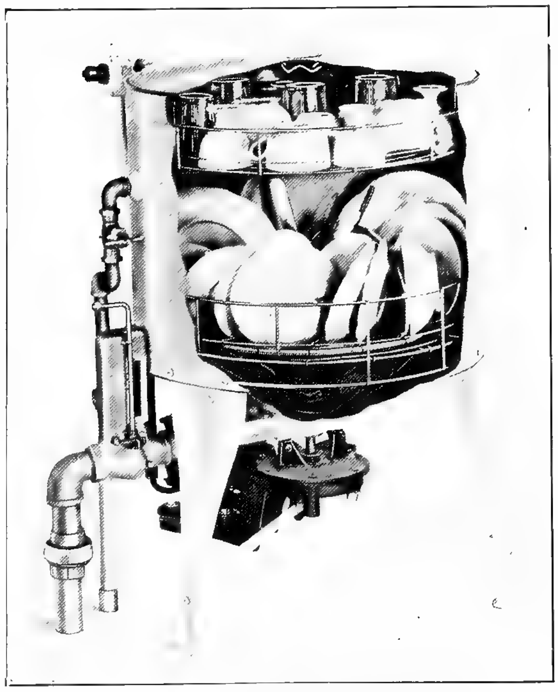
The Original Walker Tray

first model brought out was successful so far as washing dishes was concerned, but the operating principle was too severe on the machine itself.

In 1913, Mr. F. A. Walker suggested the present principle of operation, and later in the year they felt ready to present their dishwasher to the buying public. After that, a variety of hindrances, including war conditions, financial problems, etc., prevented any very aggressive development of the dishwasher business. In



The Next Model, Showing Improvement in Trays, Hinged Cover, and Wall Base



Latest Model, No. D-6, Showing Improved Cover, Electric Switch Attached to Machine, Improved Bottom or China Tray, Combination Water Gauge, Automatic Overflow and Drain Valve, Improved Leg Base. This Type is Made of Copper—rust-proof. All Previous Models were Made of Tin

August, 1920, the present model—the sixth in number—of their domestic machines was brought out. It is actually a practical and efficient machine for washing dishes in the home, and is claimed to be superior to anything else called "dishwasher" which has yet appeared.

Coincident with the bringing out of the latest model No. D-6, came proper equipment of the factory at Syracuse for volume production at minimum cost. At the same time occurred considerable expansion of the sales organization, so that with the resumption of normal business conditions it is confidently expected that the Walker Dishwasher will early take its place as one of the leaders of present-day household electrical appliances.

AMERICAN ELECTRICAL HEATER COMPANY

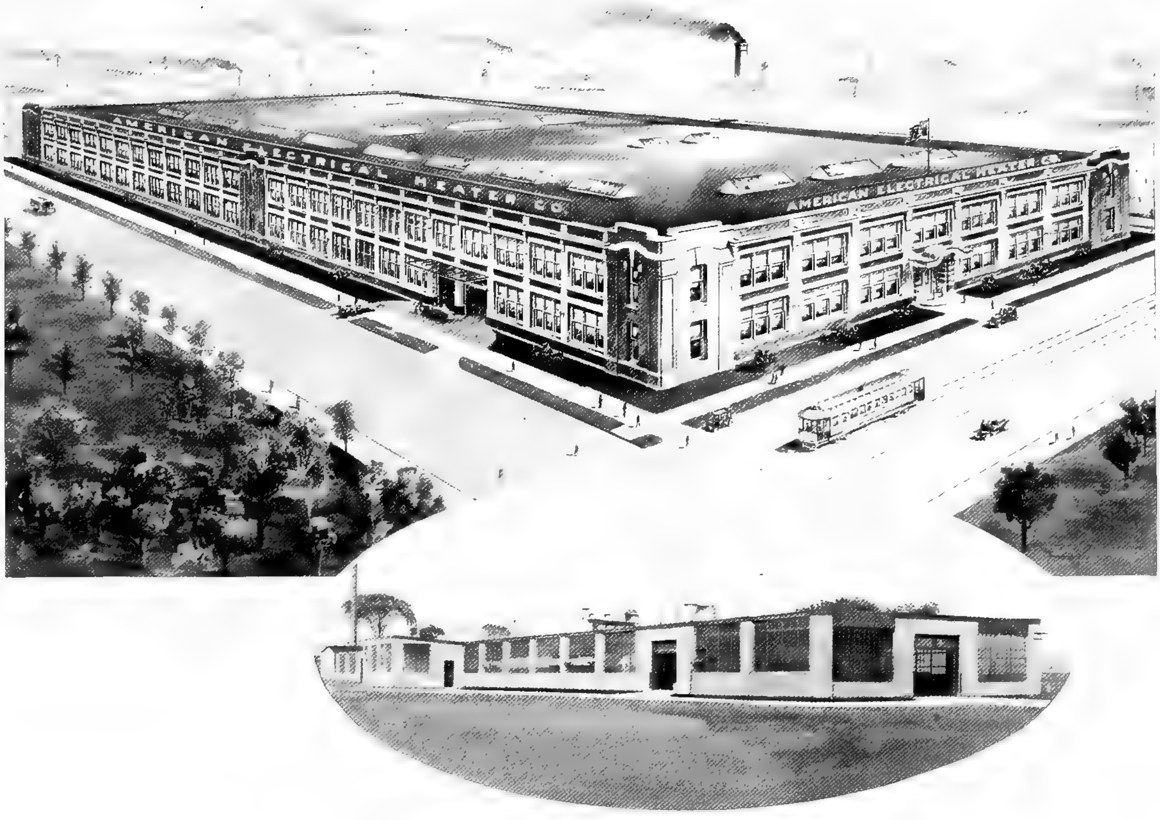
When we speak of "The Story of Electricity" we are inclined to suppose that such a narrative should deal principally with the large current-consuming propositions, such as street railways, telephone, telegraph and lighting systems, but while all of these bring added comfort and convenience, without the last of which the growth of the heating device industry would be very limited, it is doubtful if its sphere of usefulness in this field is paramount to that filled by the many and varied household and industrial devices, for, being inter-dependent, one upon the other, as the current-producing division increases its scope, so does the appliances department.

Electricity, as the heat medium in household devices, has those much-to-be desired properties of safety, convenience, cleanliness and flexibility. In the industrial line, these same properties are fully as apparent, with perhaps the added advantages of the possibility of placing machines in any desired position; the fact that losses due to friction, and the transmission of heat and power are eliminated, and that air drafts and atmospheric conditions will not affect machines thus equipped to as great a degree as do those whose functional activities are controlled by other means. As evidence that this is true, one only has to note the item of steam which, while it gives a uniform heat, is of such nature that if the temperature is raised to an undue degree it involves the question also of safety due to the great steam pressure required. This serious handicap is not present in the matter of electric temperature, and the added fact that virtually 100 per cent of efficiency is deliverable makes it nearly ideal.

Resistance coils (under the title of heating elements) applied to certain devices where heat is essential, in various cases have solved many of the problems; have lightened many tasks; have made possible added comfort and a conservation of time and of heat, and have minimized the labor of the housewife and mechanic materially. It was not so far back that the use of electricity in this manner was first deemed possible, but every added year sees its service more beneficial and more universal; sees more and more of the drudgery eliminated, and cleanliness more pronounced and more fervently demanded.

Heating elements by reason of the flexibility of the resistance agent employed may be made into nearly any shape that is desired, allowing the heat to be concentrated or diffused at such points as are most important. Heating elements are of either one or two types, the encased or sheathed element and the open or glower type. The open or glower type, owing to its pleasing appearance, is the one most often used in the household form of heating devices, while the encased or sheathed type is nearly always found on the industrial side.

Less than thirty years have passed since the first electric irons were placed on the market to supersede the old cast-iron sad iron with its weary picture of searing heat and tiresome steps, but so



Plant No. 1 Plant No. 2

Manufacturing Plants of the American Electrical Heater Company, Detroit, Mich.

well have they fulfilled their mission as promised by the manufacturers that about 75 per cent of the wired homes in the land are now so equipped for them, and they have proven so beneficial, that they have opened the way to an ever-increasing volume of other devices that have already proven so beneficial and broad in their range of usefulness as to make it probable that they will exceed in numbers the electric iron.

Many firms were brought to life in the early days of experimentation. Most of them had but a brief season of existence, but the one that passed safely through these pioneer days and is still in business is the American Electrical Heater Company of Detroit, which was organized in September, 1894, by Benjamin Scranton, John Scudder and August Tinnerholm. In the year 1904 the company absorbed the United Electric Company controlled by Robert and Frank Kuhn. The company has done business under the former title ever since, thus making it the oldest concern of its kind in existence.

From a small beginning the company has grown consistently, year after year, until now it is said to do the largest business of any company engaged exclusively in the manufacture of electric heating devices.

The officers and directors of the company are as follows: B. H. Scranton, Chairman of Board; Robert Kuhn, President; Frank Kuhn, Vice-President; Guido Kuhn, Secretary and Treasurer, and W. A. Baker, General Sales Manager.

Soldering irons were the first things manufactured, and the "Pioneer" brand of irons is still on the market—greatly improved mechanically, and still leaders in that line of industrial devices.

In 1895 were placed upon the market the "L" and "T" electric irons—supplanting the cast-iron sad iron, and the old charcoal-heated "goose" of the tailor.

The field kept broadening, and in 1896 the first electric heater was made. It might be interesting to know that the initial heater of this type was installed in the Commodore's cabin of a British man-o'-war lying at Halifax, Nova Scotia.

The shoe industry was looking for an improved "ironing" tool, and this need was met by applying electricity to the task. This innovation was launched about 1898.

That the trend of the times was more and more toward electricity became very apparent, and thus "white coal" was made to function in behalf of the busy housewife. Electric irons, toasters, toaster stoves, percolators, grills, curling iron heaters, air heater and everything that could be adapted to this new heat followed in quick succession.

When the war's needs came thick and fast, electricity was called to the fore, and electric soldering irons were found to afford the quickest method of hermetically sealing the "bread" cans for the soldiers in the field, and the airplane works also utilized these and electric glue pots, with the result of speeding production. Heaters for use of the "watch" on board vessels, and in the crow's nests, were also called for, were furnished, and fulfilled their vital mission. Air heaters in "sentry" houses and out-lying guard posts made for comfort and convenience, and were found useful in places where explosives were stored and a flameless heat was an imperative need. Laboratory plates and industrial discs expedited the work of the chemists; hot plates for the bottom of oil containers made it possible to have oil on the flying fields at just the proper consistency; hospital service was rendered easier and greatly expedited by the use of the electric grills; pain was made more bearable or alleviated by the electric warming pad.

Taken in its entirety the chapter written into history by the electrical heating industry is a proud one, and every year finds an addendum thereto that is just as fraught with progression, and the service is more and more an ever-expanding one. The field of utilization, so far, seems pretty well covered, but the field for development has probably scarcely been touched.

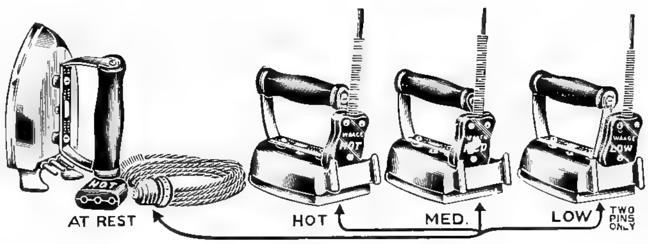
WAAGE ELECTRIC COMPANY

One of the popular labor-saving devices of the Electrical age is the electric iron, and the most appreciated improvement in the electric iron is the exclusive patented heat regulation feature of the Waage, by which absolute control of proper heat is obtained for different kinds of ironing, from the heaviest table linens to the most delicate silken fabrics.

With the compound heating element of nickel-chromium resistance wire and the patented plug in "hot" position, both sections of the element are connected in parallel giving an intense heat; with the patented plug in "medium" position, the larger section of the element only is connected, giving a medium heat for ordinary ironing; with the patented plug in "low" position the two sections of the element are connected in series giving a moderate heat which will not scorch delicate fabrics. Still another heat is obtained with the plug in "medium low" position, by which the smaller section of the element only is connected.

Today there are hundreds of thousands of satisfied users of this iron and a recent investigation showed that on heavier pieces the heat regulation improvement resulted in a saving of one-half the time and on the average ironing a saving of one-third the time.

The Waage Electric Company, manufacturers of this time-saving device, was established on March 1st, 1909. The present offices are at 12 South Jefferson Street, Chicago, and 9 Reade Street, New York. The original company was organized by Messrs. A. H. and C. P. Waage; since then Messrs. T. W. and Gilbert Waage and Leonard Steiner have been admitted to the company. The capitalization of the Waage Electric Company is \$100,000 and their annual turn-over is approaching the half-million mark.



Waage Electric Iron

The romance of this company is that it was started with only \$500 as an initial investment and it has been built up without outside financial assistance to the extensive business it is doing today. The success of the enterprise is not only attributed to the outstanding superiority of the product but to the hard work and energetic qualities of its proprietors. It has been the constant policy of the company to make a better product than its competitors, to make prompt adjustment of complaints, to give full value for the money received, and to make every user of their irons a booster for its good qualities.

THE STORY OF THE HOOVER SUCTION SWEEPER

The history of The Hoover Electric Suction Sweeper is a drama in commercial life. Its rise from an unpretentious beginning to the position of the largest-selling electric cleaner in the world, rivals the story of the orphan who was adopted by kindly people, assumed their highly respected family name, and in a few years made it many times over as famous.

To attain such success it was necessary, of course, that The Hoover embody qualities which set it widely apart from and above its competitors. These qualities are, briefly, expressed in the famous Hoover slogan, "It Beats, as it Sweeps, as it Cleans."

The Hoover Theory

The makers of The Hoover have always contended that mere "vacuum" or "suctioned air" was not sufficient to thoroughly clean rugs. Patient research and innumerable experiments have shown them that rugs could not be cleaned electrically except by a cleaner that would improve upon the age-old method of hanging rugs out on the line and beating out embedded grit.

Suctioned air, the Hoovers found, would draw away surface dirt and some litter. But experiment after experiment showed plainly that even after a rug had been treated with the most powerful current of suctioned air that could practicably be used in a cleaner, there still remained a quantity of deeply embedded, sharp, nap-wearing grit.

In other words, there were found to be three absolute essentials of thorough rug cleaning: beating, sweeping, and air suction, and these are ideally combined only in The Hoover.

The Hoover slightly lifts a rug from the floor and flutters it upon a cushion of air, gently beating out by actual physical means all of the nap-wearing, germ-laden, gritty dirt from its depths.

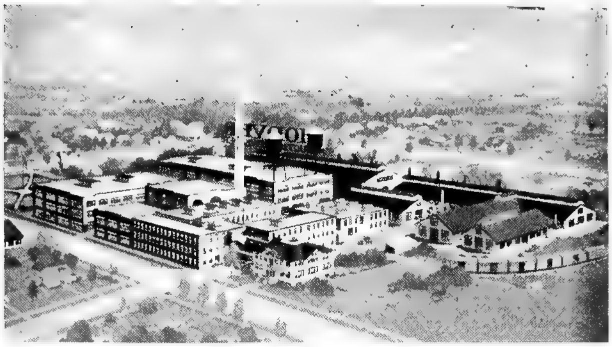
In the same rapid, easy, dustless operation The Hoover also electrically sweeps up even the stubbornest clinging litter, erects crushed nap, freshens colors while it removes all of the beaten-loose, swept-up dirt by powerful air suction.

It is this distinctive thorough-cleaning Hoover process, endorsed by rug and carpet authorities, and guaranteed to preserve rugs from wear, that enables so interesting a fact-story to be related about The Hoover.

The Industry's Beginning

Prior to 1908, comparatively little progress had been made in the development of any satisfactory means of cleaning floor coverings in the home. Sweeping probably had had its origin in prehistoric times when a cave woman pushed over the cliff with a leafy bough from a nearby tree, the remains of a dinosaur, upon which her tribe had banqueted. Down through the centuries this method changed not at all. Dirt was simply pushed across floors, or floor coverings, arousing clouds of dust which then resettled and caused additional work. The broom succeeded the bough for this purpose—that was the only change. However, the growth in popularity of woven floor coverings during the last one hundred years, led in 1858 to an attempt to provide a better cleaner than the dust-scattering, back-breaking broom. The first patents for a mechanical carpet-cleaner were taken out in that year. In 1876 the first Bissel sweeper made its appearance. These prototypes of modern cleaners, however, employed only revolving brushes. No air suction was provided to aid in the cleaning or to carry off the dirt.

They were, in fact, only mechanical brooms. Their bristles revolved instead of being brushed across the rug surface. The action upon the rug was the same—some surface litter, some loosened dirt was taken from the rug. Embedded grit, that arch enemy of rug life, still held forth in the secret depths of the nap. The machine "swept" mechanically, but it did not "beat" floor coverings, hence it was


Plant No. 1 and General Offices—North Canton, Ohio

only a trifle more efficient than the old-fashioned broom.

"Air Cleaners" Invented

In 1869 the idea of cleaning by air was born, and patents were issued. These patents disclose all the elements of modern portable "vacuum" cleaners, but not for nearly half a century did they become practical of application. This delay was due to the fact that not until around 1905 was there developed a light, high-speed fractional horsepower electric motor.

About that time a San Francisco inventor produced a successful portable electric cleaner. As far back as 1894, however, air was used to blow dirt out of passenger cars. Later a compressor was used and the dirt was suctioned up. About 1900, air-pumps were mounted upon wheels and, like a small town fire department answering a "4-11," were rolled up in front of one's door and a long hose was run into the house. $1.50 an hour for this air-cleaning work soon quenched the ardor of patrons.

In 1902 David T. Kenney, of New York, built the first installed vacuum cleaner plant, using a steam engine to drive his vacuum producer.

Not until the invention of a combined electric carpet-sweeper and electric vacuum cleaner in 1908, did anything foreshadow the great industry which was so soon to develop. A Canton, Ohio, janitor, who was also a mechanical genius, had tried to clean floor coverings by air long enough to know that air in itself was insufficient. So he conceived the idea of an electrical cleaner that would combine both motor-driven brush and air suction.

The First Hoover

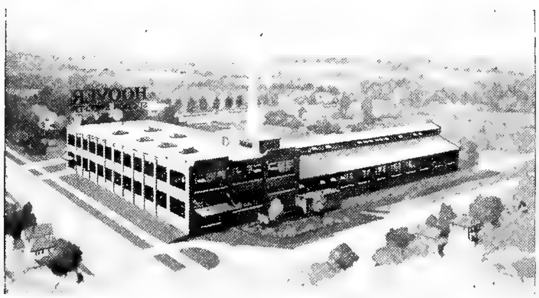
In 1908, he brought his first crude model to the W. H. Hoover Company, located nearby in a little village then known as New Berlin. For 45 years this company had engaged in the leather goods trade wherein it had attained an enviable position.

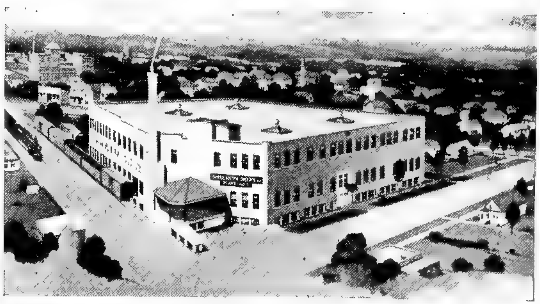
A small room in the leather goods factory was allotted for experimental purposes on the cleaner, and the Hoovers hired experts to give it interested attention.

The janitor-inventor did not live to see more than the start toward the success of his great idea, which, patiently perfected under the direction of the Hoover officials, took more and more room away from the leather goods factory.

Thus the "orphan" was marketed, having taken the name of its foster parents, Hoover.

Year by year it attained increasing sale and popularity. New buildings were erected to house the Suction Sweeper part


Plant No. 2—Hamilton, Ontario


Plant No. 3—Canton, Ohio

of the Hoover business while The Hoover itself was improved and improved.

Moreover, when The Hoover reached mechanical perfection, the beneficial influence of national advertising was enlisted to make known the virtues of this thrice-efficient cleaner to women everywhere. The slogan "It Beats—As it Sweeps—As it Cleans" was published throughout the country in magazines, in newspapers—it greeted the traveler from wayside billboards and the stay-at-homes from the windows of stores and shops—it became a household word.

Soon a world-wide interest was awakened in The Hoover. Women wanted to know what the slogan meant. They were curious about a machine that could "beat" carpets as well as "suction clean" them. They investigated—then they bought. And their neighbors and friends followed them. Sales multiplied, the prestige of The Hoover was grounded deeper in the affections of American women, and The Hoover became the largest selling electric cleaner in the world.

In a short time the demands for additional space in which to produce The Hoover were such that, after fulfilling its war contracts with the government, on January 1, 1919—eleven years after having "adopted" The Hoover in its infancy—the original leather goods firm of The W. H. Hoover Co. ceased operations in order to provide the adopted child with more room in which to grow.

"Who's Who" In Hoover

Mr. W. H. Hoover, the founder of the original company more than half a century ago, and who is to-day the greatly beloved President and Treasurer of The Hover Suction Sweeper Company, has three sons, a son-in-law and a nephew closely associated with him. His sons are Mr. H. W. Hoover, the Vice-President and General Manager; Mr. F. G. Hoover, the Associate General Manager; and Mr. D. P. Hoover, Manager of the Purchasing Department. His son-in-law, Mr. H. C. Price, is Secretary. His nephew, Mr. H. Earl Hoover, is Chief Engineer and Director of Advertising and Patents.

Plant No. 1 and the General Offices are at North Canton, Ohio, the original site. (Prior to the war the town was called New Berlin.)

Plant No. 2 and the General Offices for Canada, are located at Hamilton, Ontario.

Plant No. 3 is at Canton, Ohio, wherein are manufactured the motors for The Hoover.

The Hoover is produced in several sizes. Air-cleaning attachments are also provided. It is sold by many of the lead-

W. H. HOOVER

ing merchants in the United States, Canada and on the Continent, among whom as well as by the public in general, it is accepted as the best electric cleaner in the world.

Some Technical Reasons

It is interesting to analyze the reasons for Hoover popularity, in order to discover *why* so many people regard The Hoover as the best electric cleaner in the world. To do this let us consider the various kinds of electric cleaners now on the market. All these cleaners may be divided into four general types:

1. *Strictly suction type (including expensive installed plants)*. Having no brushes, they rely entirely upon air suction. And, as has been said before, tests prove that air alone cannot re-

move stubborn-clinging lint, threads and hairs, or dislodge heavy, embedded, destructive grit. Sweeping and beating are in addition necessary to actually remove "all the dirt."

Some cleaners of this type have nozzles which scrape across the nap. This, carpet experts say, is injurious, inasmuch as the nozzles rub off the nap.

2. *Ordinary brush and suction type.* These cleaners have brushes in or near the nozzles. In some the brushes are stationary. They collect very little clinging litter. Others have brushes *slowly revolved* by floor-rollers as in ordinary carpet-sweepers. They sweep no better than common carpet-sweepers. Nor is destructive, embedded grit dislodged by any of these cleaners.
3. *Motor-driven brush and suction type.* The brush in these cleaners is revolved by the electric motor. They sweep more efficiently as the result. These cleaners, however, keep the carpeting flat on the floor. With the carpeting pressed tightly against the unyielding floor, obviously it is impossible to shake out embedded grit, the dirt that is most ruinous to the fabric.
4. *Beating-Sweeping brush and suction type—Only The Hoover is in this class.* This type has a soft hair brush attached by a belt to the electric motor. The suction nozzle is suspended a quarter of an inch above the carpet by four caster wheels.

What The Hoover Does

The air suction of The Hoover lifts the carpeting from the floor, bringing the fabric into contact with a brush having two spiral rows of soft hair bristles. The brush is revolved more than one thousand times a minute by electricity. As the soft bristles in one row strike the uplifted carpeting its crest is depressed—and swept.

The instant the bristles pass, air suction again lifts the carpet. Quickly the soft bristles in the next row again depress the crest, sweep past, and air suction again instantly lifts the carpet. The carpet crest is thus alternately depressed and lifted—or fluttered—upon a cushion of air.

The speed with which the soft hair brush comes into intermittent contact with the suspended floor-covering produces a blow sufficient to jar loose and shake to the surface the destructive embedded dirt. The rapid sweeping detaches even the most stubborn-clinging hairs, threads and lint. And the continuous gale of air that

H. W. HOOVER

rushes through the carpeting and lifts it and draws up its surface dust, also carries off the beaten-loose, swept-up dirt into the dust-tight bag. This results in both thorough and dustless cleaning. It also airs the carpetings.

What Suction Does

The suction in all electric cleaners is sufficient to remove soot, dust and cobwebs, for it is the light, floating kind of dirt. Air currents deposit it—air currents will remove it. You can whisk away the cobwebs, soot and dust, from their every roost, by standing on the floor and using The Hoover long-armed suction attachments. You can air-clean mattresses, overstuffed furniture, portières, and the like. You can reach under and behind

radiators or into registers, collect light ashes around fireplaces, clean books, clothes, and so on, and fluff up pillows. The convenient uses for Hoover suction attachments are almost without limit.

. . .

Bearing in mind all classes of dirt mentioned—recalling that beating is necessary to remove the most harmful of all dirt, embedded grit, and that only The Hoover beats out this grit—recalling that thorough sweeping is essential to remove stubborn-clinging litter and that The Hoover sweeps thoroughly—it is apparent that The Hoover is the only electric cleaner which actually "gets all the dirt."

Moreover, The Hoover saves valuable minutes and hours by cleaning carpetings while they remain on the floor; by eliminating the removal and lugging about of furniture; and by lessening the time required for dusting. In fact, The Hoover cleans in a fraction of the time required by old-fashioned methods.

The cost of electricity to operate a Hoover averages but one and one-half cents an hour, which amounts to far less than the average family's expense for new brooms. Money usually spent for having rugs and carpets cleaned can be saved by using The Hoover. And floor coverings are kept clean and sanitary the entire year.

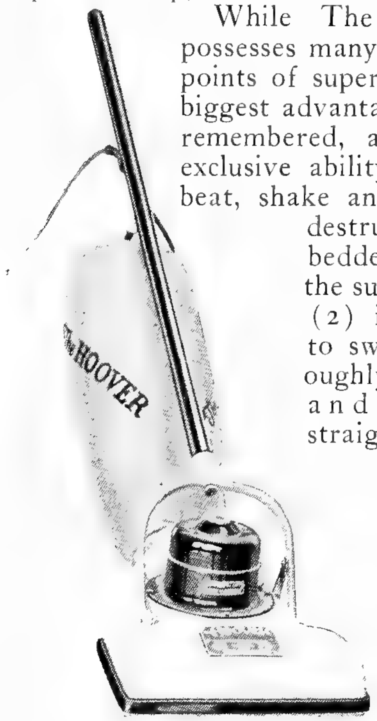
A Liberal Guaranty

The life of any rug or carpet which is cleaned regularly with The Hoover is *guaranteed* to be greatly prolonged. The oldest and largest makers of electric cleaners stand back of this guarantee. Proof that The Hoover has a beneficial effect upon floor coverings is demonstrated by its use upon millions of carpets and rugs over a period of thirteen years.

The fluttering action of the Hoover soft hair brush upon the carpeting, suspended upon a cushion of air, is very gentle. It is totally unlike the violent beating a rug or carpet receives when struck with a hard carpet beater. But The Hoover removes the dangerous, destructive grit far more thoroughly. The great difference is that The Hoover process is life-prolonging. Oriental rug importers and carpet manufacturers are strong endorsers of The Hoover.

Another great advantage in using The Hoover is that it brushes the crushed-down nap upright into its intended position. Furniture and feet mat down and crush the nap. This subjects carpetings to abnormal wear and robs them of their attractive appearance. The thorough sweeping of the Hoover Beating-Sweeping Brush lifts and straightens the disarranged nap. Patterns again become clear. And of course when the nap is thoroughly cleaned and straightened the colorings brighten. The Hoover in this manner also further prolongs the life of carpetings, because the natural wear then comes on the top of the nap, and not on the sides.

While The Hoover possesses many exclusive points of superiority, its biggest advantages, be it remembered, are in its exclusive ability (1) to beat, shake and vibrate destructive, embedded grit to the surface, and (2) its ability to sweep thoroughly, to erect and brush straight all nap bent over or crushed by traffic, as well as to brighten colors and revive patterns, while (3) its powerful air suction is removing the dirt—all these essentials of thorough cleaning being performed in one rapid, easy, dustless operation which its makers *guarantee* will add years to the life and beauty of floor coverings.



The Hoover Suction Sweeper

This, then, is the Hoover story. It is an interesting story from a human, as well as a technical, standpoint. It is the story of men working with just one ideal—to build the best electric cleaner that their ingenuity and research and honest work could fashion.

CHAPTER XVI

THE STORIES OF KINDRED ELECTRICAL INTERESTS

THE OHIO BRASS COMPANY

IT is only a little over thirty years ago that The Ohio Brass Company was organized. The capital was small, the employees were few in number, and the manufacturing facilities were limited. But the ideals of the founders were high and their ambition unbounded. They aimed to profit through service. How well they have attained their goal can best be judged by a glance at the company's history and a consideration of its size and standing today.

In the beginning, the new company manufactured valves and carried on a general brass foundry business. But it was only a short time until it identified itself with the electric railway industry by the execution of an order for overhead trolley material received from one of the new street railways in a nearby city. From that day the connection between the new manufacturing company and the infant electrical industry became more and more intimate.

Early Quarters of The Ohio Brass Co., 1888 to 1898

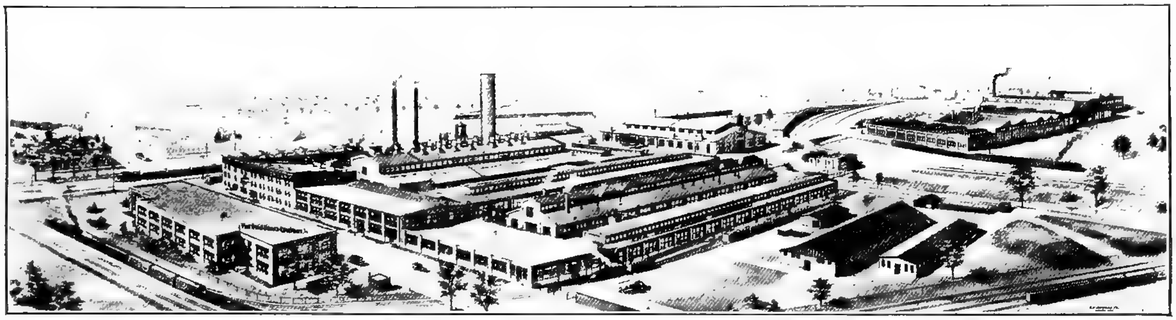
Careful attention was given to improvement and development of the articles making up the trolley material line. Hard rubber, used at first as the insulating medium, was superseded by a composition insulation first purchased from an outside source but later made in the company's own factory. From this, through constant experiment and improvement, was developed the present "Dirigo Insulation" used in all O-B trolley hangers.

Since the early days, there has been a constant program of improvement in the design of trolley materials. Adoption of electric haulage by mines and industrial properties called for trolley materials different in design from those used by electric railways. There is a complete line of O-B materials for these needs. In recent years, malleable iron has replaced bronze to quite an extent in trolley construction. This condition, together with the increasing need for malleable iron in other products, caused The Ohio Brass Company to erect its own malleable iron foundry in connection with the Mansfield factory.

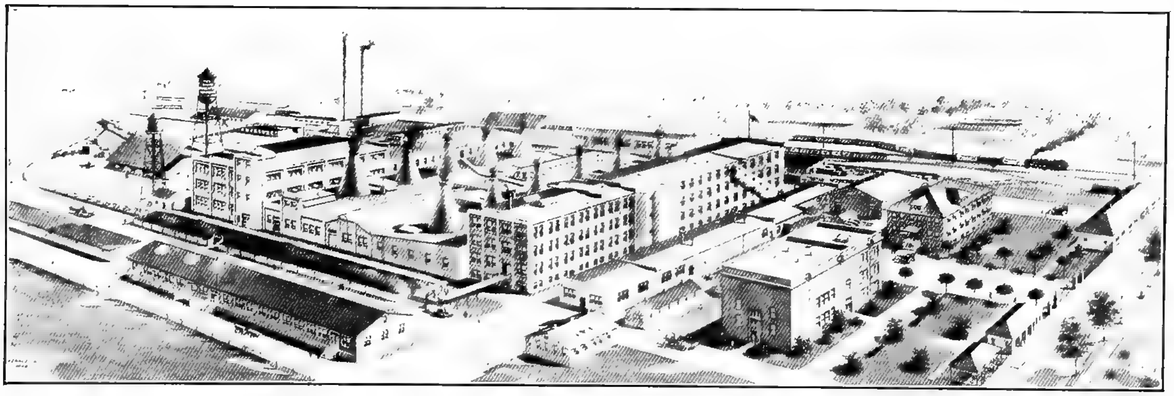
The manufacture of rail bonds began a few years later and it offered a fertile field for development work. Successive catalogues show many types of bonds, each an improvement over its predecessors and each coming a little nearer to solving the problem of a minimum-resistance return circuit. Bonds welded to the rail by the gas

flame or the electric arc have been offered within the last few years. The first commercial installation of welded bonds in America was of O-B gas weld bonds put on a steam road electrification in 1915.

In the matter of equipment specialties for electric cars, the company has confined itself to a few items for which its engineering talent and manufacturing facilities are well suited. The leader among them is the Tomlinson Coupler which is now found in use on many of the most important city and interurban properties. Trolley bases, catchers and retrievers are other important items.



Main Office and Works of The Ohio Brass Company at Mansfield, Ohio—1921



The Ohio Brass Company's Insulator Factory at Barberton, Ohio—1921

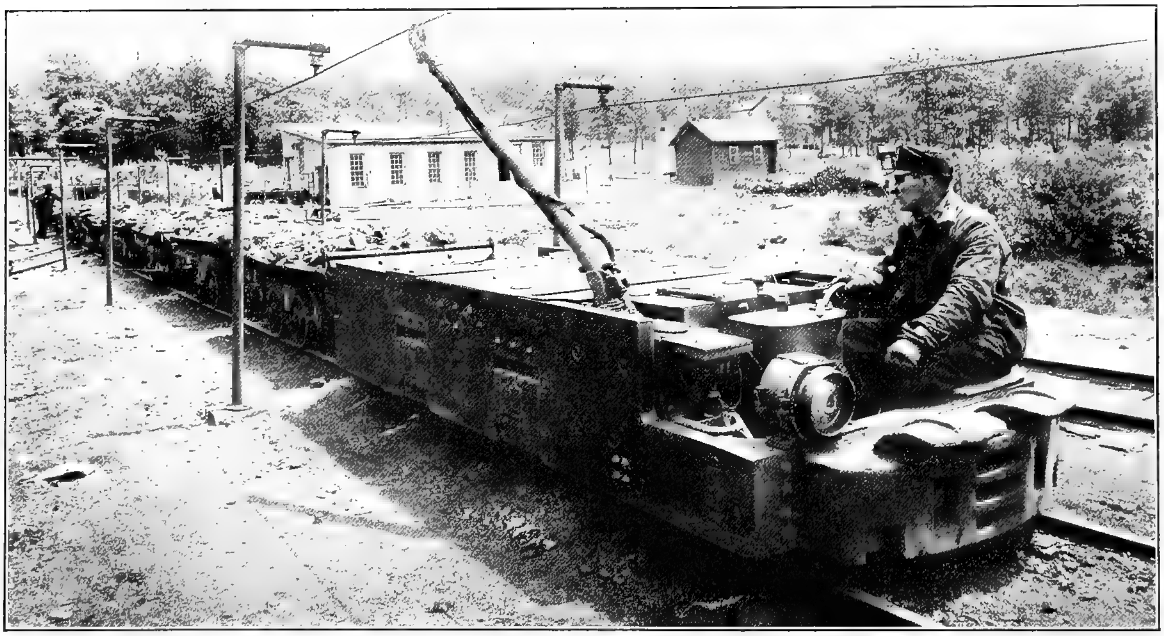
Transmission line insulation was given but little attention by operators in the early days of electric railway and central station history. Lines were short and voltages were low, so that almost any design of insulator would operate satisfactorily. But, as lines grew in length and voltages increased, it was realized more and more that the line insulator was of extreme importance. In fact, the development of the transmission art depended greatly upon the ability of the insulators to perform their function.

For several years The Ohio Brass Company controlled the output of an insulator plant in Barberton, Ohio, until it finally purchased the factory in 1910. From that date there was inaugurated a consistent policy of improvement in both design and manufacture of porcelain insulators. Today the product is found in the stations and on the lines of the large power distributing companies, not only in America but in many other countries as well.

During all these years of expansion there have been naturally many changes in the organization and the manufacturing facilities.

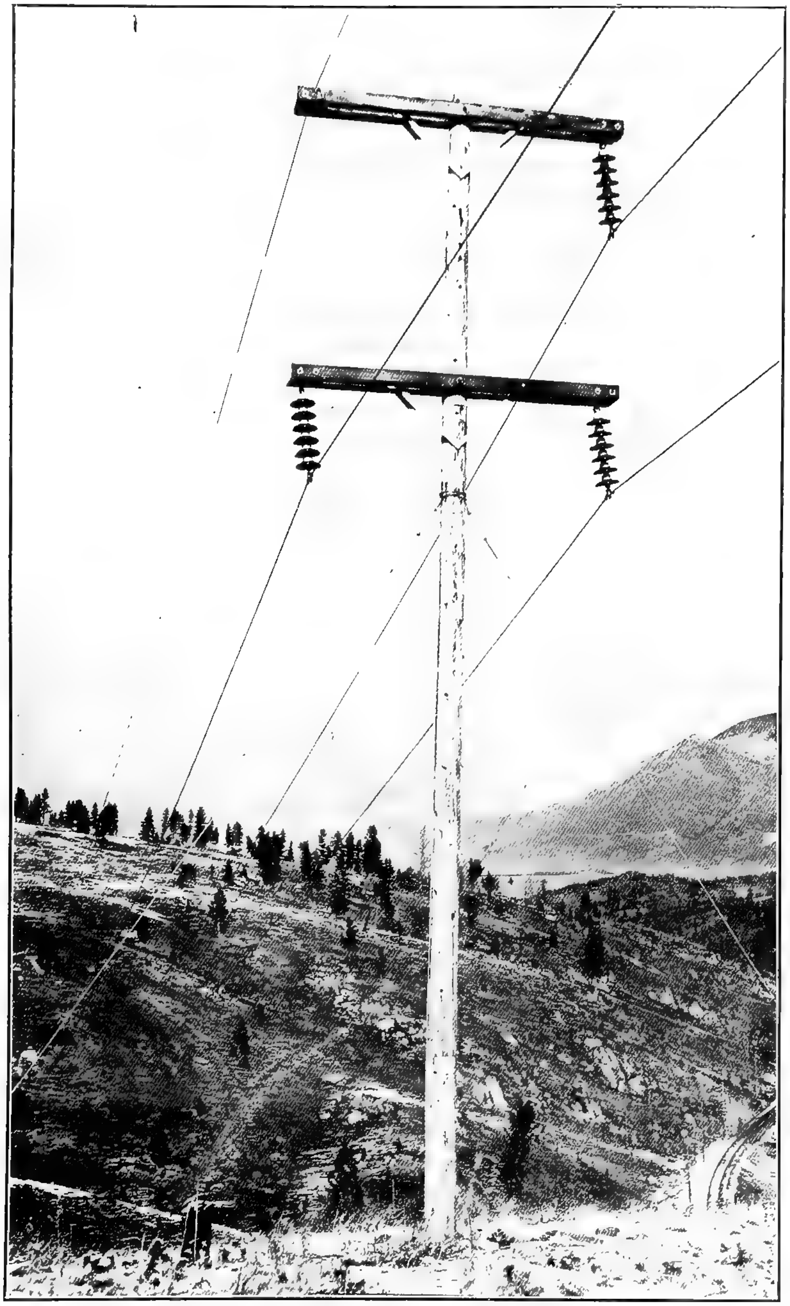
Small quarters in a rented building served to house both factory and office during the first ten years following the organization of the company in 1888. At the end of the decade, the company purchased, in 1898, a group of factory buildings on the site now occupied by the main

O-B Trolley Materials, Rail Bonds and Car Equipment Specialties are in Use on Most of the Prominent Trolley Roads of the Country. This Picture Shows a Nine-Car Interurban Train Using Tomlinson Couplers.



Typical of the Mine Haulage Systems Using O-B Trolley Materials and Rail Bonds. Locomotive in the Picture is Equipped with Crouse-Hinds Imperial Headlight for which The Ohio Brass Co. is Exclusive Sales Agent.

offices and factory at Mansfield. Business was continued in these buildings until 1905, when the entire plant with the exception of the office building was wiped out by fire. Before the ruins were cold, arrangements had been made for temporary manufacturing help, and plans were being drawn for a group of new factory buildings, laid out in such a manner as to systematize and simplify all the processes incident to the manufacture of the company's products. Additions have since been built around this group, but always in the nature of an enlargement upon the

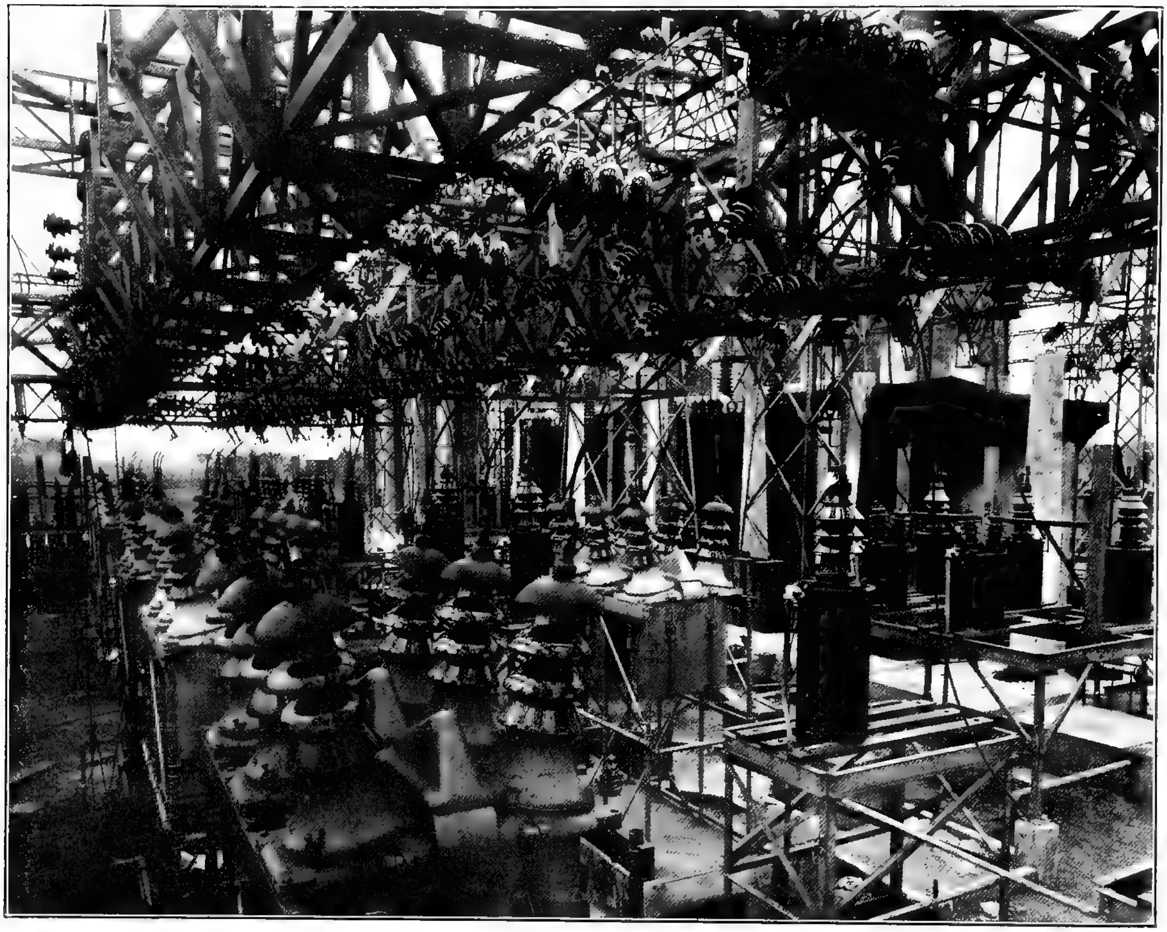


O-B Suspension Insulators in Service on Lines of Montana Power Co., Supplying Energy for the Electrified Section of the Chicago, Milwaukee & St. Paul Railway.

plan conceived after the fire. The result is a thoroughly coördinated factory. It is here that the company manufactures its brass valves, trolley materials, rail bonds and car equipment specialties.

The factory at Barberton, Ohio, is devoted entirely to the making of porcelain insulators and is considered a model establishment for the purpose. Processes and routine have all been put on a scientific basis, resulting in a thoroughly standardized and dependable product.

The Ohio Brass Company began business with a force of 20 men and a total paid-in capital of $5,000. Today, after less than thirty-five years, it occupies two immense factories, employs about 2,000 people and is backed by a capital and surplus of $5,000,000.



O-B Insulators in Substation of American Gas & Electric Co. at Canton, Ohio

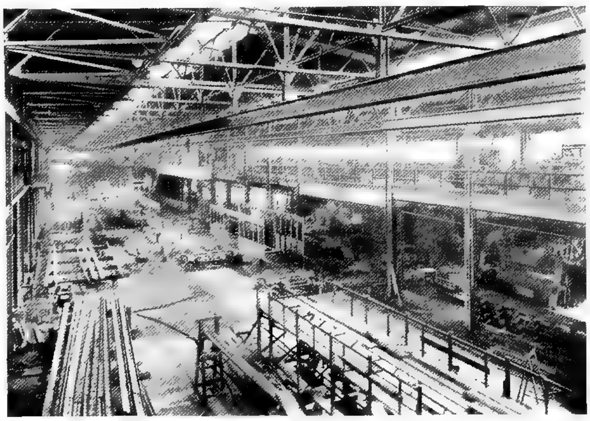
Steady growth has resulted from close application and specialization in a few chosen lines. The entire efforts of the organization have been concentrated on close study of operating needs and constant endeavor to improve designs and quality of O-B materials.

Electric Railway Cars and Trucks are the Principal Products of this 30-Acre Plant of THE J. G. BRILL COMPANY, Philadelphia, Pa.

THE J. G. BRILL COMPANY

(Electric Car and Truck Builders)

The application of electricity to the street railway car as propelling power was unquestionably responsible for the rapid advance which the industry made following the successful demonstrations in various large cities, subsequent to those in Baltimore in 1885 and Richmond, 1887. What was formerly a mediocre industry grew to enormous proportions, and to this growth is also attributed the remarkable development of many of the largest cities and towns. The ability to transport large passenger loads to outlying regions in so much shorter time very quickly widened the cities' limits and stimulated every activity where suitable means of transportation proved a determining factor.



Where Steel Electric Railway Cars Are Built

Street railway transportation was not a thing which every community enjoyed, and neither was it necessary until the electric street car made possible the development which was then unknown to many cities and towns. A comparatively small number of companies were in existence in the days when horses and mules provided the only means of propulsion then known to mankind for the purpose, and when it is considered that there are today in the United States upwards of 1,000 electric railways, city and interurban, with a trackage of some 50,000 miles, some idea is obtained of the progress which this industry has made. There is represented an investment of $5,000,000,000, a capitalization which ranks first in public utilities after the steam railroads. Statistics for the year 1920 show that the electric railways had in service 105,588 cars, 85 per cent of which are for passenger use, and that every year some 14,000,000,000 people are transported, which

is ten times the number of passengers carried by the steam railroads of the country.

The electric railway car aside from its powerful motors, controlling devices and operating mechanism, may be said consists of two parts—the carbody itself, with its complement of seats, ventilators, drawbars and bells, and the trucks. Many progressive changes in street railway car and truck design were necessary to permit the use of electricity as motive power, and with the further development of the industry, many important innovations, which mean greater comfort, convenience and safety to the public, have been produced.

The Brick Building in the Center was Built in 1870 and was the first of the Original Brill Plant in Philadelphia

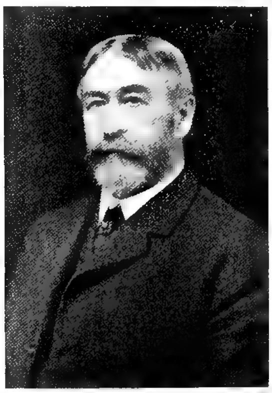
The J. G. Brill Company, Philadelphia, foremost builders of electric railway cars and trucks in the world, have contributed some of the most important inventions covering cars and trucks and car and truck parts. In fact the history of this company and that of car and truck building in the United States are practically identical. While not the first builder of street railway equipment in the world, the Brill Company is the oldest in continuous service. The John Stephenson Company, for several years operated as a Brill subsidiary plant, was founded by the "Daddy of the street railway car," John Stephenson, who built the first horse car in 1831, to be operated along Broadway in New York City.

In 1869 John G. Brill and his son, G. Martin Brill, two sturdy foremen in the employ of Murphy & Allison, Philadelphia, one of the largest car builders, started in business in a small way for the purpose of building horse cars, which part of the business had been given up by their employers. This enterprise was under the name of J. G. Brill & Son. Within two years these mechanical geniuses, which they then and later proved to be, purchased a site at 31st and Chestnut Streets, Philadelphia, and built a substantial brick building. In 1872 the need of additional capital to carry on the then rapidly increasing business attracted James Rawle, who purchased one-third interest and the firm name was changed to

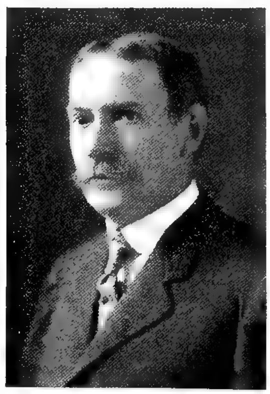
PRESIDENTS OF THE J. G. BRILL COMPANY

JOHN G. BRILL
1887-1888

GEORGE M. BRILL
1888-1906

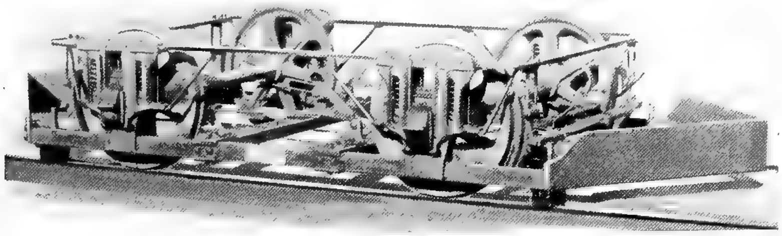


JAMES RAWLE
1906-1912



SAMUEL M. CURWEN
1912-—

J. G. Brill & Company. Their industriousness, their determination and their ingenuity, which enabled them to build cars to meet the most radical ideas of purchasers in the United States, Mexico, Cuba and other countries, early indicated their success.



The First Electric Car Truck having an Independent Frame for the Motors

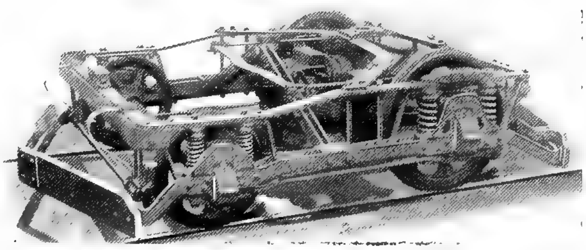
Although San Francisco experimented with the cable car as early as 1873 horses or mules continued to be the sole method of railway car propulsion until the early 80's when grip cable installations were made in many of the larger cities including Philadelphia, Pittsburgh, Cincinnati and New York. The high cost of installation doomed this method of propulsion for localities outside the big cities, and demonstrated the need of propelling power adapted for general use and which would be more satisfactory than the grip cable system proved itself to be.

JOHN A. BRILL
Vice-President 1888-1908
Inventor

Realizing the possibilities of the electric railway and in preparation to meet the demand for equipment, which it recognized would follow, the firm was incorporated as J. G. Brill Company under the laws of Pennsylvania, in 1887, with the founder, J. G. Brill as president; G. Martin Brill as vice-president and general manager; James Rawle, treasurer and secretary; and John A. Brill, manager of sales.

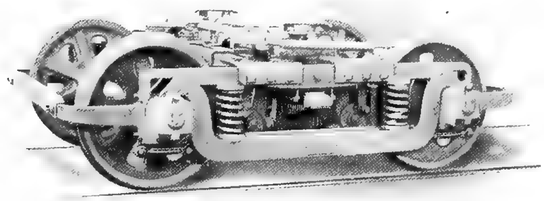
John A. Brill, the youngest son of the founder, had been engaged in the business practically from the beginning as a bookkeeper and clerk, and was ably fitted to take his place alongside his father and brother in the great business which had been established. In addition to being peculiarly constituted to handle the distribution of the company's products, John A. Brill possessed a very keen inventive mind from which evolved many new and practical ideas in connection with rolling stock, to meet operating conditions on street railway properties. He was one of the first to recognize the need for a truck with an independent frame on which to mount the motors to propel the electric car and, as a result, in 1888, the Brill Company started the production of the first system of electric trucks known to the industry.

The first type produced was an adaptation from the horse car running gear, and it is an interesting fact that the method of motor suspension



First "Maximum Traction" Truck, Brill No. 11, Built in 1890

adopted for this first truck has continued down to the present in universal service. From this there were developed several similar types with the introduction of spring posts with the springs on top of the built-up frame instead of encased in the pedestals as in the first single truck.



Brill High-Speed Truck No. 27MCB. Constructed with Solid-forged Sideframes

On September 22, 1888, the company had its first real reverse in the death of its president, John G. Brill, and the industry lost a man whose enterprising spirit had contributed so much to its development. G. Martin Brill succeeded him as president, with John A. Brill, vice-president and manager of sales.

Success crowned the electric railway from the start, its business increased rapidly and it was soon realized that larger carbodies were necessary. No type of truck had been developed up to this time to permit the use of longer cars, so it devolved upon the Brill organization to meet the need. Mr. John A. Brill in his truly characteristic way in 1890 produced the first "maximum-traction" pivotal truck as the solution of what was looked upon at that time as a most difficult problem. The necessity for designing a type of double truck which could be placed close to the ends of the narrow carbody, avoiding the steps and sills, and which at the same time would satisfactorily radiate on the then-existing curves, was responsible for placing the truck bolster out of center and using a pair of wheels of smaller diameter and a pair of the ordinary size. Provision was made for a distribution of the weight so that the larger wheels carried nearly all of it. The importance of this invention is best illustrated by the fact that the "single-motor" truck which is generally accepted as the type best suited for city operation under large cars is a "maximum-traction" truck and is the same in principle as the first truck of this type built. Many other types of trucks were designed and constructed according to the ideas of the Brill staff, and with which John A. Brill was most prominently identified.

When in 1890 the Brill Company moved to a plot of ground, 62nd Street and Woodland Avenue, at the intersection of the Pennsylvania and Baltimore & Ohio Railroads, it laid the foundation for its present plant, which is modern in every sense—layout and equipment. Mr. John A. Brill in his desire to improve his company's product was instrumental in the adoption of the system of making all truck frames solid-forged in one piece, which is a feature characteristic of Brill trucks at the present time. As in many other instances he thus displayed the most remarkable foresight and recognized the necessity for the production of trucks capable of satisfactorily meeting the most exacting requirements of city and high-speed interurban service with less liability of breakdowns and accidents.

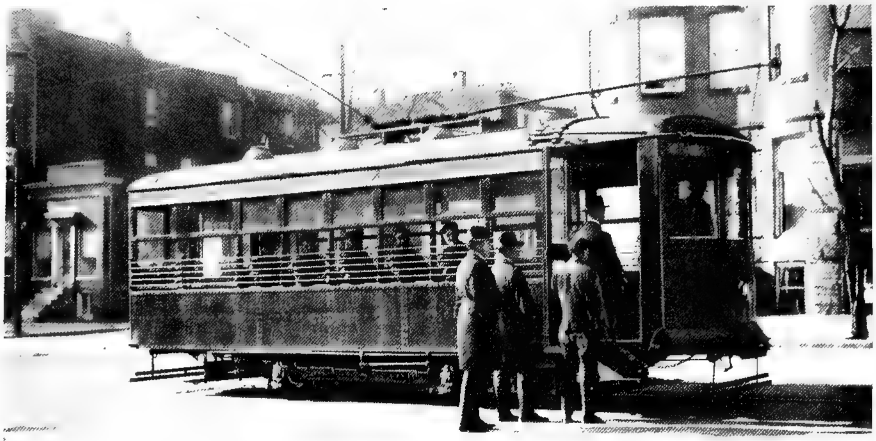
Then followed numerous improvements in carbody design as well as trucks, having to do with both passenger and special purpose types of cars, and the contributions of

One of the Early Types of Electric Street Cars

the Brill engineers to the industry in this respect are to be found today on cars all over the world.

Business expansion proved the inadequacy of the Philadelphia plant, which had been enlarged from 18 to the maximum of 30 acres, and in recognition of the advantage of saving in freight charges to

western points, the company purchased the American Car Co., St. Louis, Mo., in 1902. Later for the same purpose in other sections, the G. C. Kuhlman Car Co., Cleveland, Ohio, and the John Stephenson Company, Elizabeth, N. J., were taken in 1904, the Wason Manufacturing Co., Springfield, Mass., in 1906, and the Preston Car & Coach Co., Preston, Ont., Canada (operated as "Canadian Brill Co., Ltd.") in 1921. With the exception of the Stephenson Company, which was sold and put to another use, all these plants are still engaged as Brill subsidiaries in the construction of cars for either electric or steam railways.



Modern Birney Safety Car

G. Martin Brill, the second president of the company, died in March, 1906, and was succeeded by James Rawle, the secretary and treasurer. Although it was necessary for this pioneer to depart, the organization, which he had built up so successfully, was destined to go on and, if possible, continue to play even a more important part in the progressive march of the electric railway industry. Edward Brill, the third son of J. G. Brill, who had joined the company in 1880 and had been in charge of the lumber department since 1888, was elected treasurer.

With its reincorporation in 1906 the company's name was changed to "The J. G. Brill Company" by which it is now known, and the capitalization increased to $10,000,000.

With the death, in 1908, of John A. Brill, who had been vice-president for twenty years, the industry lost a man who

Peter Witt Front-entrance Center-exit Car

undoubtedly in many ways had contributed as much as any individual to the development of electric railway cars and trucks. His ability to offer practical solutions of difficulties in car and truck construction has resulted in almost one hundred patents being issued to him, many covering important inventions which live on as a monument to his memory.

While his predecessors at the head of the Brill organization were men more concerned with production, it remained for James Rawle to possess those qualifications necessary to administer the company's financial affairs, and his ability in this respect can only be judged by the company's success, much of which resulted from the wise and carefully planned policies which he adopted. His death in March, 1912, was a severe blow to the organization, but Mr. Rawle himself helped to build the foundation upon which the business was built, and the progress of any company so firmly established was not to be retarded even upon the death of its president.

Samuel M. Curwen, the general manager, then took up the reins of leadership, with Edward Brill, vice-president and treasurer, Henry C. Esling, secretary since 1908, and W. H. Heulings, Jr., manager of sales. Mr. Curwen served his apprenticeship in the company's shops on Chestnut Street, and besides being a practical car builder is also a self-taught mechanical engineer. Many valuable patents owned by the company are for his inventions, and he is recognized in the electric railway industry not only for his ability in the administration of his company's affairs but also for his interest in matters pertaining to the entire industry.

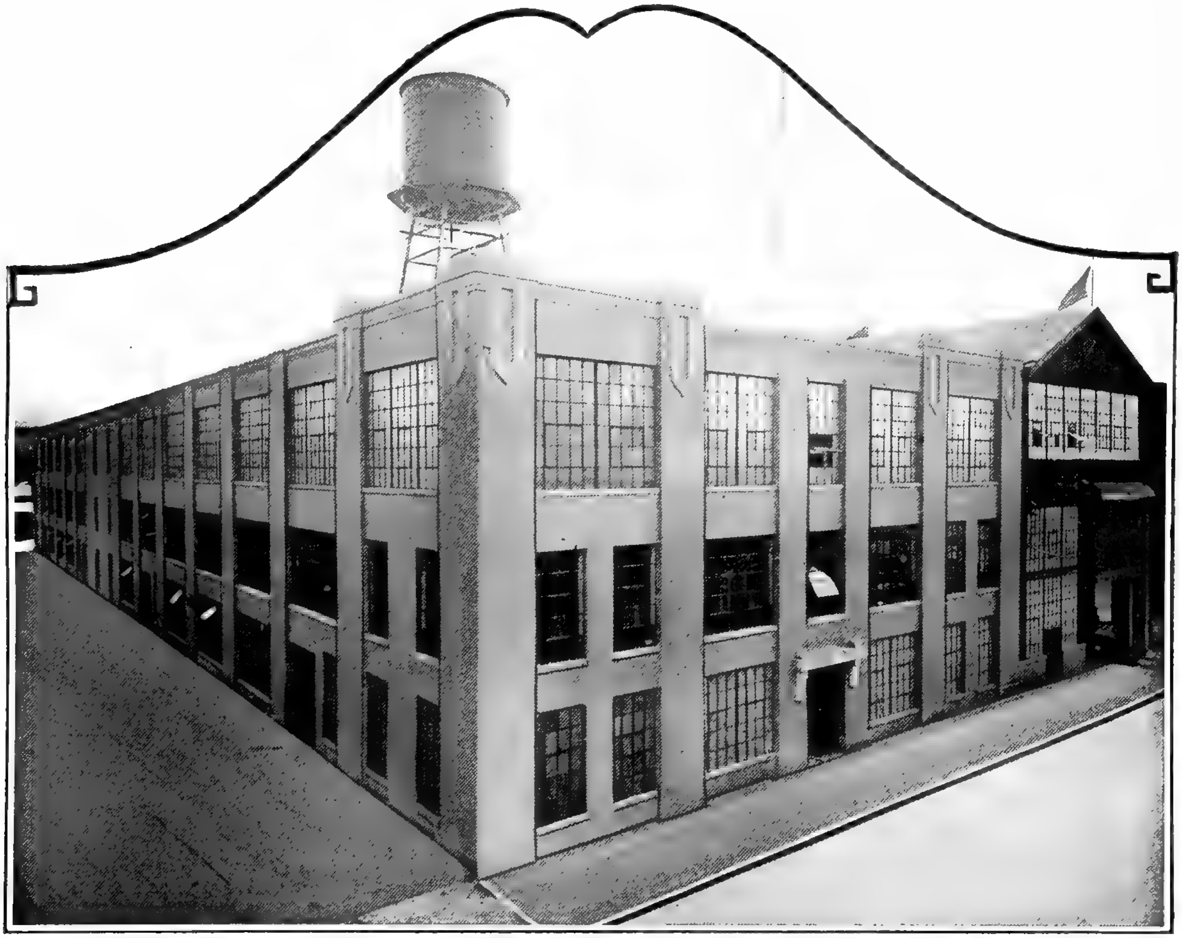
At the death of Mr. Edward Brill in 1914 W. H. Heulings, Jr., was elected first vice-president, retaining his office as manager of sales, with J. W. Rawle, a nephew, and Edward P. Rawle, a son of the late James Rawle as second vice-president and treasurer respectively. Henry C. Esling, the secretary, died in September, 1921, and was succeeded by Ed. L. Oerter, who had been comptroller of the company for ten years.

The present tendency in car design for city cars is along standard lines. In the interest of conservation of labor and material in production and power and human life in operation, there was designed the light weight Birney Safety Car, a novel type which has practically revolutionized the principles of electric railway service. A large number of smaller light weight cars on shorter headways can be operated at less cost with fewer accidents due to highly developed safety devices. For unusually heavy traffic in peak periods the Peter Witt front entrance center-exit car has been adopted. Quick loading and unloading are its principal feature. Double entrance and exit doors, and with the conductor on the forward side of the center-exit doors, collecting fares on the pay-as-you-pass system, greatly facilitate the handling of large crowds in the quickest time. Each of these two standard designs of cars bears the name of its originator, but the Brill Company and its subsidiary plants collaborated in their development, and have constructed over seventy-five per cent. of the cars of these two new standard designs produced.

The scope of the Brill business is best gauged by the fact that either cars and trucks of Brill manufacture are in operation in practically every civilized country in the world. Over 50,000 cars and 175,000 trucks have been built in the Philadelphia plant alone.

THE PITTSBURGH TRANSFORMER COMPANY

The Pittsburgh Transformer Company was organized as a partnership in 1898, and has steadily grown and advanced since that time, becoming in the last twenty-four years, it is said, the largest exclusive manufacturers of transformers in the United States. The company, as now known, was incorporated in 1910 under the laws of Pennsylvania and Mr. R. V. Bingay was then made the president, occupying that position ever since. In spite of many opportunities and earnest invitations to take up other lines of production, the company has steadfastly refrained from undertaking any other work than that pertaining directly to standard transformers and strictly allied apparatus. From a small and modest beginning, the works have grown until they now occupy no less an area than three city blocks; while in 1917 a substantial up-to-date factory addition was made in the Juniata Plant. This fac-



PITTSBURGH TRANSFORMER COMPANY, JUNIATA PLANT
(Columbus Avenue Entrance)

tory is replete with modern equipment and its lighting is the best and latest possible, conforming to the ideas and principles laid down by the Commonwealth Edison Committee on Lighting through Mr. Durgin. It may be noted that the lamps are placed on an angle about half way up the bay, and the results are very satisfactory. The plumbing and toilet arrangements on rigorous specifications have been carried out in the finest and most complete manner by the contractors. Individual wash basins and shower baths are provided on every floor.

The plant is sprinkled throughout. The large crane is run by energy from the circuits of the Duquesne Light Public Service system; and the elevators are also of the alternating current type. As the plant is in the immediate vicinity of the great Brunot's Island power plant, facilities are enjoyed of practically unlimited current supply for transformer testing.

R. V. BINGAY

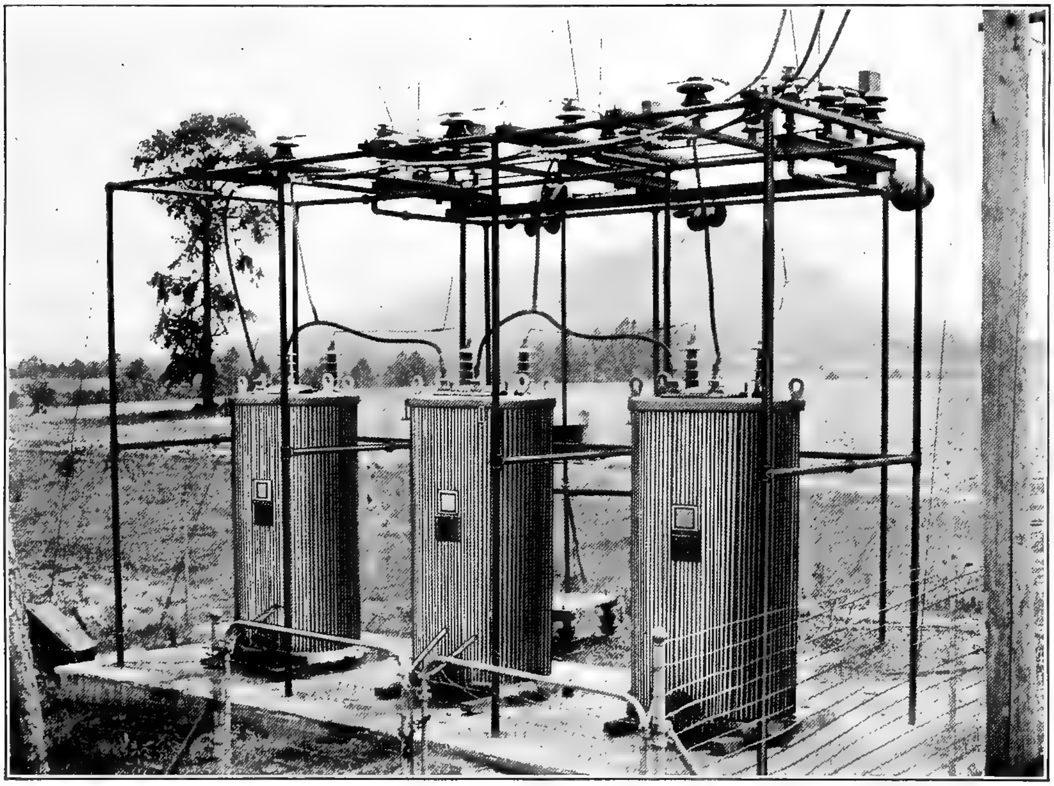
PRESIDENT PITTSBURGH TRANSFORMER COMPANY

"At the age of 50 I find myself," remarks Mr. Bingay, "one of the oldest members of the electrical industry, having been almost thirty-three years engaged in the manufacture of transformers, having started practically with the first transformers made in this country, and also on the first alternating current machine designed by Dr. Elihu Thomson." Such a fact does indeed show, as he intimates, how young the electrical industry is. Mr. Bingay was born September 7, 1871. After education in the public schools, he was ready when only 17 to begin in 1888 building dynamos and motors with the Royal Electric Company of Canada, and was soon deep in the construction of transformers, then a quite novel application. But

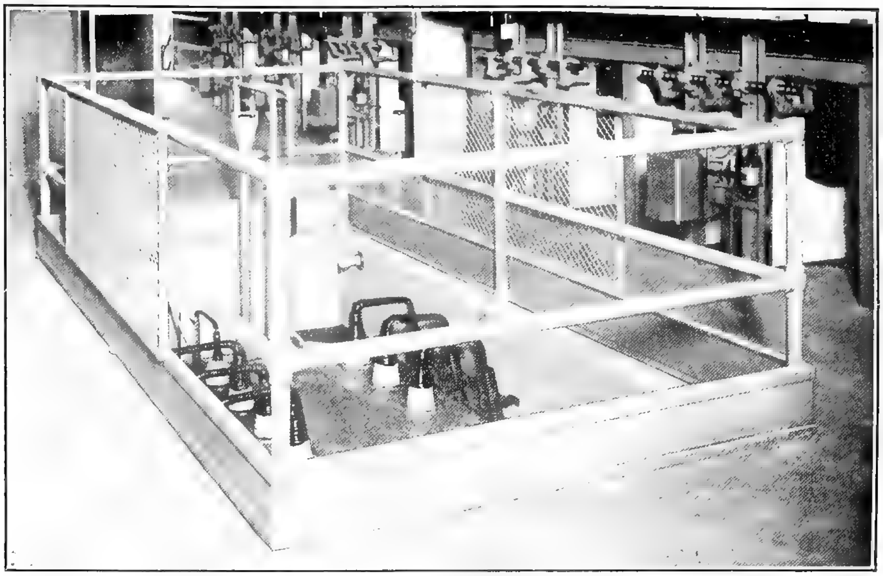
PITTSBURGH TRANSFORMER COMPANY, JUNIATA PLANT
(Interior View Erecting Shop)

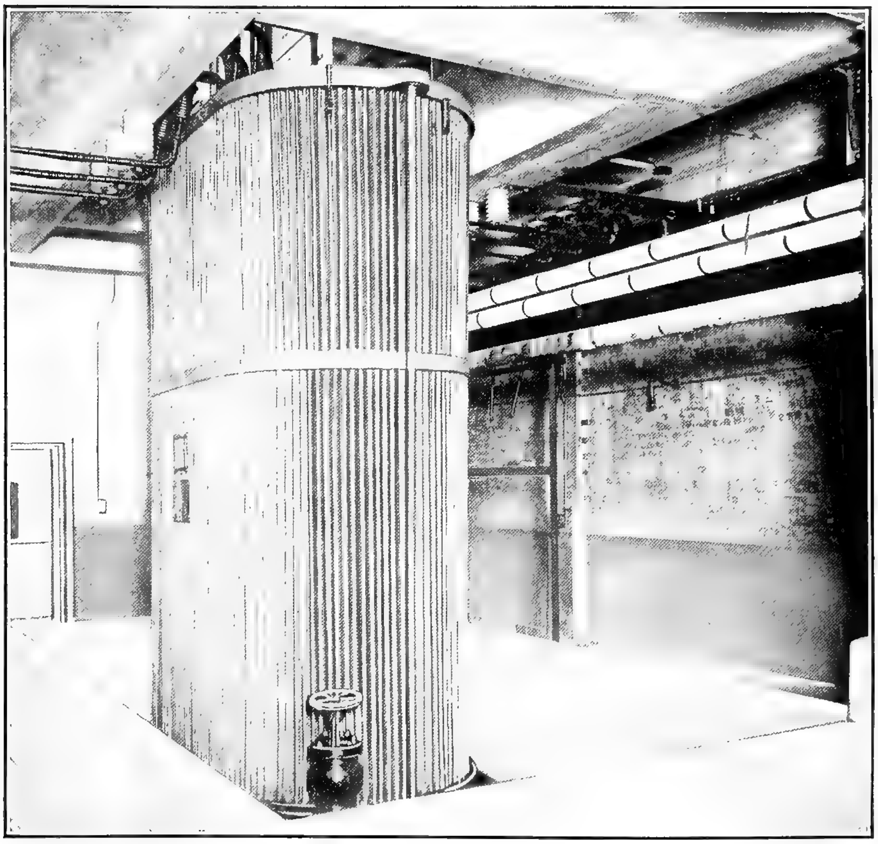
R. V. BINGAY

apprentice work and assisting in the laboratories at McGill had given him already such training and insight that he was quite able to grapple with the design and manufacture of such apparatus, for which there were no models as precedents, and whose efficiency and perfection depended entirely on the skill and judgment brought to bear on the work. It was inevitable that Mr. Bingay should make very rapid advances in the field in which indeed he may justly be said to have spent his whole life with concentrated devotion. The fourth line of transformers in America was of his design and construction, and in the well-known Pittsburgh Transformer Company he has since that time built up the largest independent business of the kind in the country. He started with the company in 1900 as a partner, and in developing it up to its present distinctive position he has been president since its incorporation and the largest individual shareholder. The achievements not less than the basic inventions and continuous improvements of the company are of his creation or due to his initiative. Evidence of close study of the art and the electrical field as a whole is furnished in Mr. Bingay's illuminating statement: "I have attended the National Electric Light meetings for over 25 years, and I believe I am one of the oldest regular attendants at its conventions; as there are few of the men left who took part in those gatherings when I first participated. The growth and changes in those meetings are very marked: in the pioneer days it was more of a pleasure and get-together occasion, and was troubled very little with technical and educational work such as is now the great and worthy aim." Besides his membership in the National Electric Light Association, Mr. Bingay is a member also of the allied Pennsylvania



PITTSBURGH TRANSFORMER COMPANY
Three 300 KVA, 55° C., Self-Cooled Transformers, 44,000 Volts
Manufactured for the Southern Power Company





PITTSBURGH TRANSFORMER COMPANY, CRAGIN SUBSTATION
Standard Method of Installation of Three-Phase Units
Developed by the Engineers of Commonwealth Edison Company

Electric Light Association, as well as of the American Institute of Electrical Engineers, the Electric Power Club, and the Electric League of Pittsburgh. He is also a director of the North Side Board of Trade of Pittsburgh; member of the Chamber of Commerce and Union Club; also a Mason, A.A.N.M.S.

During the Great War Mr. Bingay was an active member of the Central Liberty Loan Committee of Western Pennsylvania, and chairman of the Manchester Liberty Loan Committee, etc. It is typical of his patriotic spirit that with him originated the idea of "100 per cent." in the war activities of Pittsburgh. "The first 100 per cent. plant and the first 100 per cent. community in the United States was, we believe, the Pittsburgh Transformer Company in the city of Pittsburgh," and as bearing on this a letter to Mr. Bingay from ex-Secretary of War Baker, may be quoted as follows: "Let me say to you a word of very sincere and very hearty thanks and congratulations for your letter of October 12th telling me of the splendid reception which the Second Liberty Loan has had among the people of your organization. I wish it might be possible for me to convey the sense of gratitude which I feel, to each of them; but that being impossible, may I not ask you to say to all of them that such coöperation as theirs is tremendously heartening and cheering to those of us here who are merely trying to do our duty as it is given us to see it." Mr. Baker did not say things like that without meaning it.

AMERICAN TRANSFORMER COMPANY

The American Transformer Company which has for its slogan "Custom Made Transformers" and which makes a specialty of catering to solve difficult transformer problems usually avoided, or at least not desired or understood by other transformer manufacturers, was established in 1901 by Mr. Anson F. Harrold, whose untimely death occurred as far back as 1907.

Mr. Harrold was a graduate of Princeton, 1892. He was an athlete of distinction and was "tackle" on Princeton's football team '91–'92 and was honored by being selected by Walter Camp for "tackle" on the All-American Team of '92.

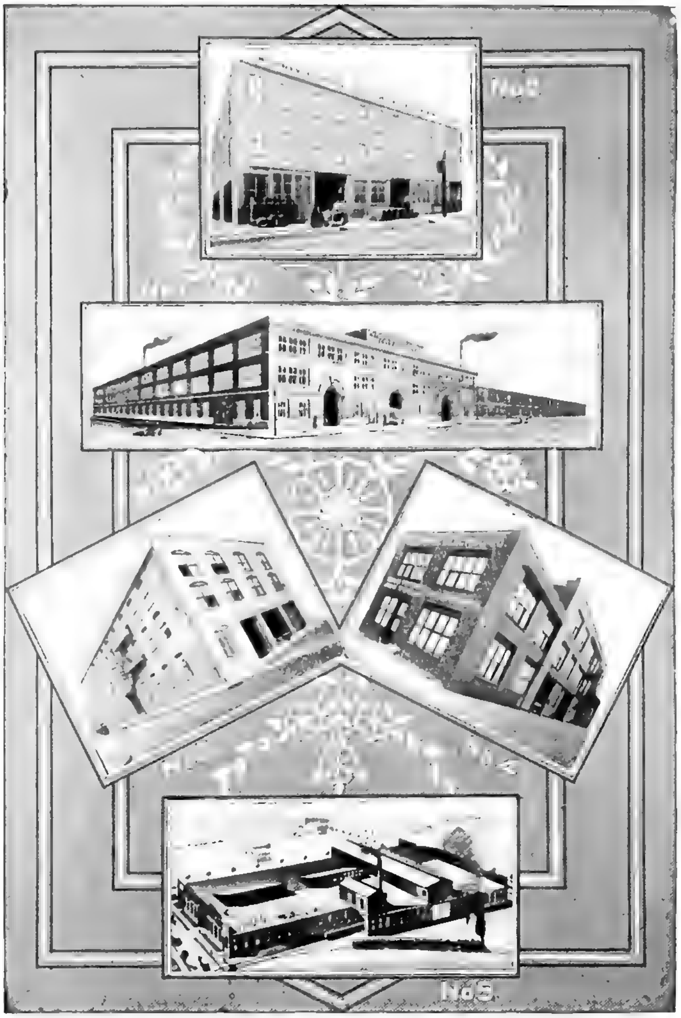
Warren F. Hubley, who succeeded as president and treasurer upon Mr. Harrold's death, started with the company at the lathe and bench in 1901 after attending college at Franklin and Marshall. He thus advanced through all branches of the business from bench to the president's desk. Mr. Hubley has also been treasurer of the Institute of Radio Engineers since 1914. The vice-president and secretary of the company is Mrs. M. H. Harrold, widow of its founder.

The American Transformer Company is especially prepared to handle unusual and difficult problems in transformer manufacturing. The business has doubled in the last few years and employs about 50 expert mechanics who are especially familiar with this line of manufacturing.

The company's offices are located at 178–182 Emmet Street, Newark, New Jersey.

MOLONEY ELECTRIC COMPANY

Based upon the patents and inventions of Mr. Thomas O. Moloney, of whom a biographical sketch appears in this volume, the Moloney Electric Company was organized in St. Louis, Mo., in February, 1897. Its history is quite a large part of the record of the transformer art in America. As far back as Faraday's classic experiment in 1831, with two coils wound on a soft iron ring, the fundamental idea or principle had been known in the art, but it was not until 1883-4 that Gaulard and Gibbs in Europe, and William Stanley, Jr., at Great Barrington, Mass., laid the foundations of the modern manufacture and use of the transformer without which the world-wide utilization of electricity could not have been effected. The Stanley system seen in operation by Mr. George Westinghouse in the pretty little Berkshire town in 1886, was absolutely a point of new departure for electric light and power, the electric railway, electrical long distance transmission and a whole range of new arts hardly dreamed of when young Thomas O. Moloney addressed himself to a study of the whole subject. As he has tersely remarked



Moloney Transformer Factories

himself: "In the early years in which the alternating current was being introduced, the transformer, or, as it was then called, "the converter," was a piece of apparatus that gave much trouble to its operators. Necessarily, much time was given to the repair of transformers, and it was the desire to lessen and abolish such expensive troubles that induced me to devote all my thoughts and energies toward the perfection of this vital class of apparatus out of which has grown my life work." The electrical industries have traveled fast and far since that time, but perhaps as good an idea of what that means may be found from one little fact. According to the U. S. Census of manufacturers in 1900, the total production of transformers in that year was only $2,962,871 for the whole United States, whereas the Moloney transformer alone has reached an annual output of $3,500,000 a score of years later.

The officers of the Moloney Electric Company are: T. O. Moloney, president; James J. Mullen, vice-president; Hugo Wurdack, secretary; and S. B. Butler, treasurer. The capitalization of the American Company is now $700,000 all employed solely in transformer production, with many advantages from the central location of St. Louis with its 26 trunk lines of railroad there converging. The corporation employs an average of nearly 300 skilled workers, chiefly American, and prides itself worthily on the quality of its apparatus as well as the ability of its staff to deal with the new problems that constantly arise. There is a flourishing branch of the Moloney interests in Canada, at Windsor, Ontario, just across the river from Detroit.

THOMAS O. MOLONEY

The founder of the well-known Moloney Electric Company of St. Louis, Mr. Thomas O. Moloney, was born April 27, 1872, in Jersey County, Illinois. The early years of his life were spent on a typical Midwest farm, while he attended the district schools; afterwards going to the High School at Jerseyville, Ill. When about 18 years of age he removed to the not far distant city of St. Louis, and became an employee of the old Laclede Gas Light Company, with which he remained until February, 1897, a period of six and a half years. It was the critical time when the alternating current was coming into its own, affording large opportunity to a young man with unusual powers of observation and invention, so that increasing experience daily suggested to him needed improvements in the electrical arts. Almost from the start in 1890. he began to invent, design and improve alternating current apparatus, but it was particularly on the transformer that he bestowed his energies and activities; meanwhile with private instruction mastering mathematics and electrical principles, now so absolutely in his grasp. A brief review of his successive achievements is quite interesting.

In 1891, Mr. Moloney—barely 20 be it noted—filled transformer tanks with oil to provide insulation between primary and secondary coils—the insulation in some makes consisting of only a quarter inch air space. A year later he devised and built an indicating wattmeter fashioned after the Siemens dynamometer, using a stationary potential coil on the dynamometer instead of a current coil. In 1893 in connection with the work of ascertaining the temperature of the field coils of direct current machines, he used the increase of resistance methods. In 1896, he wound core type transformers, interconnecting the secondary coils of the legs so that they would operate an unbalanced secondary load.

By this time the variety and number of his inventions had opened up a new vista, and instead of operating the apparatus then available, he followed out an irresistable impulse and became himself an electrical manufacturer. Thus it came about that in 1897 he organized the Moloney Electric Company—of which more is said under that heading—and he has been associated with that prominent and progressive concern down to the present time; its sole business being the manufacture of transformers, the improvement and perfec-

tion of which may well be said to have constituted his life work, so that today no name of a living expert in the field is better known than his. The advances due to his genius are so numerous it is difficult to recapitulate all of them; but special note may be made of the fact that in 1907 he adopted the use of silicon steel for transformer coils; this being the first such use in the United States. Four years later, in 1911, he found it necessary to establish a Canadian branch, known as the Moloney Electric Company of Canada Limited, with plant at Windsor, Ontario. The American and Canadian Moloney enterprises are literally enjoying a demand for their productions from every country where the alternating current is in use.

Mr. Moloney has thus established a place for himself among the American inventors of his time while still on the sunny side of fifty; and in spite of engrossing professional and industrial occupations, has always found it a pleasant task to impart to others the valuable knowledge he has accumulated from a rare experience. Moreover he has taken an active interest in his chosen field of work, as well as in

THOMAS O. MOLONEY, President

national and civic matters of broader scope. He is a member of the American Institute of Electrical Engineers, National Electric Light Association, the Engineers Club of St. Louis, Manufacturers Association, St. Louis Chambers of Commerce, Missouri Historical Society, the St. Louis Club, Missouri, Athletic Association, Midland Valley Country Club, Sunset Hill Country Club, Old Colony Club, B. P. O. Elks and the Knights of Columbus. These suffice to indicate his active life interests.

LOCKE INSULATOR CORPORATION

About 27 years ago, to be exact, in 1895, there was formed in Victor, N. Y., a company headed by Mr. Fred M. Locke to engage in the manufacture of porcelain insulators for high tension electric power transmission. Mr. Locke was the first person in the world, so far as known, to conceive the idea of using porcelain insulators, and to engage in their manufacture, for actual transmission line service. On account of the insistent demand for an insulator that would withstand "high voltages" the announcement of the new "Locke" Porcelain Insulators created such wide interest among electrical engineers in the United States that the first plant, which consisted of but one small frame building and a brick kiln, was unable to manufacture insulators in sufficient quantities to meet the demand.

If, in the beginning, there had been any doubts in the minds of any of the American engineers as to the practicability of the "Locke" theory, these were soon dispelled by the records of the porcelain insulators in service, and the realization of the fact that here was an insulator that was capable of development to the point where the highest practical voltages could be transmitted with the minimum interruption and energy loss. It was also an insulator that could be manufactured on a commercial scale at a cost which resulted to the user in a reasonably priced article.

While the earliest designs of "Locke" insulators were possibly ten years ahead of the service requirements at the time, the development of electric power transmission was so rapid that it was only by being in the closest touch with this expansion that the Locke Company through its experimental and research work, was able to produce insulators of a design and quality to meet the requirements. Since the first porcelain insulators were manufactured, the Locke Company has never ceased its experimental and research work, and this coupled with its continuous records of actual insulator performances in every kind of service, under all conditions and in all climates, has enabled the company to successfully meet the demand for insulators for higher and still higher voltages.

The Locke Company is the oldest and in fact the largest manufacturer of electrical porcelain for high power transmission. The plant at Victor, N. Y., has seventeen large size kilns and the new factory at Baltimore, Md., has eight kilns of still larger size, all devoted entirely to the manufacture of wet process, high tension electrical porcelain, a capacity approximately twice that of any other manufacturer. The Baltimore plant is of the latest design and represents the best ideas of modern engineering and manufacturing. It can readily be enlarged to 24 kilns and plans are ready to increase the size to meet the demand for the product.

In its own laboratories, and in conjunction with the General Electric Company, experimental and research work is conducted today on a scale scarcely dreamed of even five years ago. It has moreover searched the accessible world for the raw materials that are best suited for electrical porcelain, and its processes have been perfected through 27 years experience in a new world of application.

The officers of the company are as follows: Donald Symington, president; J. F. Symington, vice-president; F. H. Reagan, operating vice-president and general manager; J. F. Douty, Jr., secretary-treasurer, and R. C. Morrow, assistant secretary-treasurer. The executive offices are at Baltimore, Maryland.

ROME WIRE COMPANY

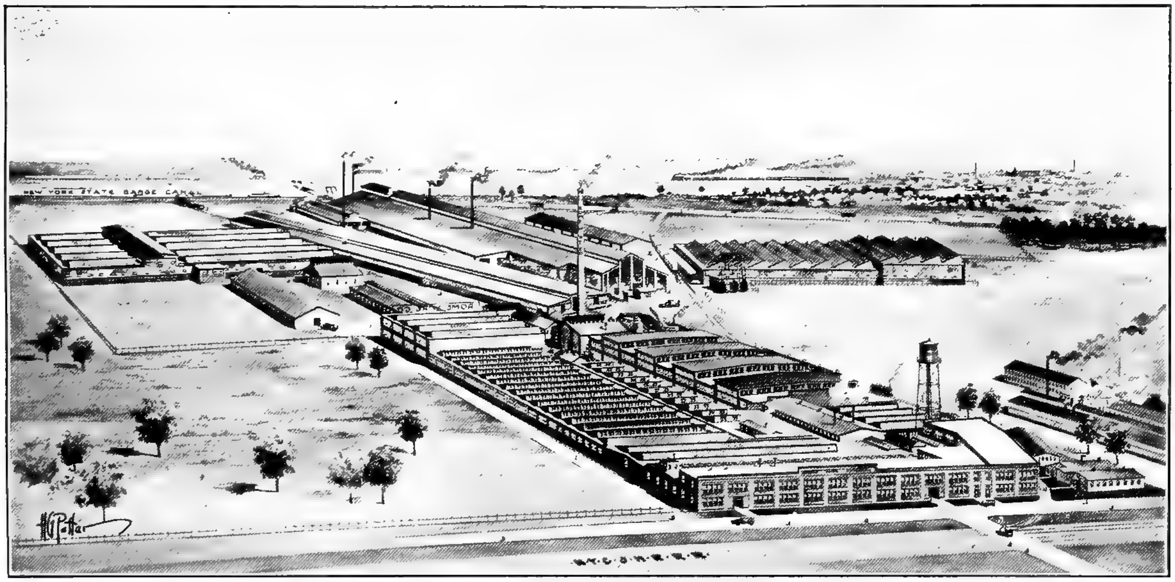
The story of insulated wire and cable manufacture has never been told, and even the few facts here noted are not commonly known. An Englishman named Moore, who settled in Philadelphia, appears to have made covered wire for Prof. Joseph Henry in the early thirties for some of his experiments in telegraphy. Thomas Davenport, who made the first electric motor, tore up his wife's silk wedding dress about the same time to insulate his little wires. About 1857 the patent of F. Bridges for putting braid on whips was used to put it also on wires; and Bridges was employed by S. C. Bishop, who himself was one of the founders of the art of covering wire with gutta percha in America. Siemens in Europe had made gutta percha wires as far back as 1846-7, when several miles of it, protected outside by lead pipe or tube were laid in Berlin. As far back as 1849, G. B. Simpson applied for a patent on the insulation of electric wires by glass beads, and seven years later he sought to patent a method of applying a solution of gutta percha over a metallic wire with a brush. Some of Morse's earliest aerial circuits were painted with tar or with a coat of wax; and James D. Reid, who did this, mentions the interesting fact in his "Telegraph in America" that in 1847 a piece of gutta percha insulated wire was successfully tried near Elizabeth, N. J., for telegraphic work and a similar piece was laid at a drawbridge over the Passaic River, New Jersey. In 1848, a patent was issued to Durant for a solution of insulating gutta percha by chloroform; and in the same year J. N. Alvord laid a gutta percha covered wire in lead pipe across the Mississippi River at St. Louis. It broke and in the next year he put down another span armored with No. 9 iron wire, which worked admirably.

Apparently all the pioneer insulated wire made in America was for such purposes as just described. Mr. Eugene F. Phillips referring to his ledgers of 1874, states that he believes he made the first braided wire used for any "outside" purpose, the purchaser being the "parent" but infant American District Telegraph Company. The material seems to have been similar to the "tubing" put on flexible gas connections, but even as early as 1847 rudimentary wire bound with cotton appears to have been used to run through window frames. This seems to have been like the cotton-covered wire used in crinolines of the day. The use of braided wire was very limited until the stock-ticker came along, when the demand for its 3-wire circuits, as well as the messenger box, created a brisk demand. Then came the epoch-making telephone in 1876 with its infinite interior application; and naturally the manufacture of insulated wire, both braided and paraffined or "waterproof," enjoyed a tremendous impetus. "Annunciator" wire, which had been used in call bell and hotel work proved to be very handy for telephonic subscriber connections, and its use was succeeded by an enormous application of "telephone cords". Barely had all this got going before the development of the electric light industry opened up an entirely new field for insulated wire and cable, dating say from 1881, so that the later period in the development of the industry has now reached its fifth decade.

It is easy to understand that the art though simple and desultory in its beginnings is today complex and highly differentiated; and this is perhaps best anticipated in contemplating a list of the products of such a typical manufacturer as the Rome Wire Company, which begins with hot rolled copper rods and draws also bare copper wire in all its varieties of round, square and rectangular, plain and tinned; and includes also polished copper piano covering wire, reaching, practically at the other end of the scale, to copper trolley wire. Next in order may be said to come the group of "weatherproof" wires; and then is reached an extensive group of rubber covered wires, which may be summed up as follows: Na-

tional Electrical Code Standard Wire; fixture wires, lead covered cables, flexible cords, deck cable, brewery cord, heater cords, telephone wires, bridle wires, jumper wires, gathering locomotive cable, mining machine cable, special flexibles, thirty per cent wire, forty per cent wire, super service cords and cables. And if this were not enough, to it all may be added a distinct group of automobile wires and cables, such as charging cables, ignition wires, starter cable, lighting wire, horn wire, gas and engine cable. To all which may be further added a variety of special wires and cables "which no man can number" for export and domestic use. A far cry from the wire made near Rome about a hundred years ago by that enthusiastic young Vermont blacksmith, who did not hesitate to tear into strips the wedding dress of his tearful little bride, that the wires of the first American motor could be insulated!

Incorporated August, 1905, under the New York law, the Rome Wire Company succeeded, by the change of name to the Wire & Telephone Company, of America, which had combined the Electric Wire Works and the Empire Wire Company, both of Rome, N. Y. In May, 1920, a subsidiary concern, the Electric Rod Mill of Rome, was also merged. Starting in a modest way the company has grown until it now ranks as one of the largest in the United States engaged exclusively in the manufacture of electrical wires and cables. The capital stock outstanding of the company consists of $1,854,700 of preferred and $2,474,000 of common. The officers are H. T. Dyett, President; F. M. Potter, Vice President; C. R. Keeney, Secretary and Sales Manager; H. W. Barnard, Treasurer; and Moss A. Kent, Superintendent. All the officers are residents of Rome, and are not only active in the management of the Company but take a very active part in the life of the city, which is an unusually progressive community. In addition to the executive offices at Rome, sales offices are maintained at 50 Church St., New York City, 14 East Jackson Blvd., Chicago, 25 Parsons St., Detroit, and 336 Asuza St., Los Angeles, Cal.



Rome Wire Company. General Offices and Works—Rome, N. Y.

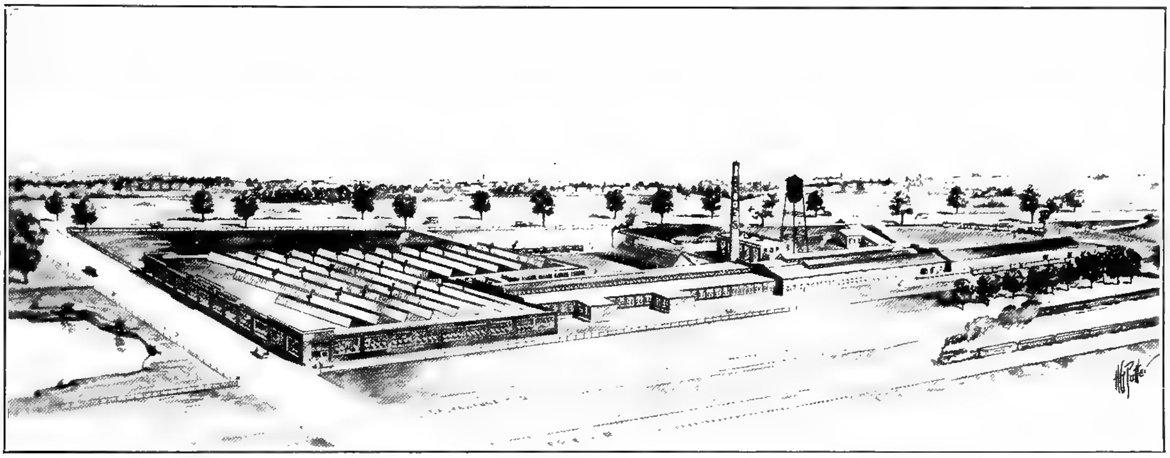
The main plant of the company at Rome is located on 37 acres of land, with

direct connection with the New York Central Railroad and adjacent to the New York State Barge Canal. The factory floor space consists of 539,000 square feet, all constructed since 1906 of the most modern type of factory construction. Almost all of the buildings are one story, saw-tooth construction, giving maximum of light and ventilation. The whole plant is fully protected by sprinkler equipment.

Rome Wire Company installed the first electrically driven copper rolling mill in the country. All of the company's equipment is driven by electric motors, rated at approximately 7,000 h.p.

In December, 1919, the company purchased the wire drawing and insulating departments of the well-known B. F. Goodrich Company of Akron, Ohio, and moved them to a new plant at Buffalo, N. Y. This is now operated as the Diamond Branch, specializing in flexible rubber-covered wires and cables for all purposes. The buildings at Buffalo contain 130,000 square feet of floor space, all of which are sprinkled, and they are entirely modern, unusually well laid out for the manufacture of electrical conductors; they have private sidings, direct connected with both the Erie, and the Delaware, Lackawanna & Western railroads. The combined facilities of the two plants at Rome and Buffalo place the corporation in the front rank of the industry in the production of rods, bare wire, rubber covered wires and cables, and magnet wire.

Contained in the Rome plant is a complete laboratory, which carries on continuous and exhaustive chemical and physical tests of materials entering into the finished products of the company. Another and very interesting self-contained department is that devoted to the manufacture of diamond dies. The diamonds are imported in the "rough," and only those that meet the exacting tests of the department are accepted. While the diamond die department is maintained primarily to insure a constant supply of high grade, accurate dies for the company's own use, many other wire mills are furnished with dies from this source.



Diamond Branch, Buffalo, N. Y.

The Company believes that the man who has an interest in the Company for which he works makes the best employee, and its employees were therefore given an opportunity to invest in the preferred stock of the Company some time ago on a very liberal, partial payment plan. Over 90% of the foremen and 50% of the employees of the Company are stockholders. The Company issues to each employee who has been with the Company

for over one year, a life insurance policy of $500, which increases $100 in value each year until the maximum of $1,000 is reached. The Company also maintains a very well equipped hospital with nurses always in attendance and operates a first class restaurant.

While the Company has had an unusually rapid growth in the last few years, it feels that its facilities will be taxed within the next few months due to the demands of old customers and the constantly increasing lists of new customers. They believe the electrical industry, as has so often been stated, is still in its infancy and that a large percentage of growth in this industry will be seen in the next few years.

SQUARE D COMPANY

In the accompanying sketch somewhat more personal of Mr. Bryson D. Horton, the president of this company, a brief outline is given of his various inventions, which are produced and marketed by the Square D Company, 6000-60 Rivard Street, Detroit, Mich., which was established 1903. The company makes a specialty of the Square D safety enclosed switches, in manufacturing which it employs some 700 persons, chiefly American citizens, and has a capital and assets of over $1,000,000 devoted to the enterprise. It is said to be the largest single manufacturer of enclosed electric safety switches in the world, as well as a pioneer in that field. It has also produced the "Arkless" enclosed electric fuses, 1903-17. The main factor in bringing success to its business has been the recognition of the great hazard to the public from the use of electrical devices having exposed bare contacts, and inventive skill in supplying the necessary protection. Detroit itself is credited by the management as being responsible for a portion of its success. Its strong Board of Commerce, its enviable location, its good labor conditions, have all been factors in helping its manufacturers to attain success. This company has also been a persistent and intelligent advertiser.

The Square D Company was organized by Messrs. B. D. Horton, F. C. Massnick, and George I. Berridge. The present officers are: president, B. D. Horton; vice-president, Z. D. Patterson; secretary, A. MacLachlan; treasurer and general manager, T. J. Kauffman.

BRYSON D. HORTON

Very often a man's career is summed up not only in his inventions but in the business mechanism he organizes to manufacture them. This is true of Mr. Bryson D. Horton, of Detroit, Mich., the president of the Square D Company of Detroit, which produces apparatus made under his patents.

Mr. Horton, who is a descendant of Barnabas Horton, one of the original settlers of Long Island, was himself born far from salt water, at Fenton, Mich., Sept. 28, 1871. He graduated from the University of Michigan, a good enough student as his history shows; but he is inclined to think that one of his chief distinctions was an "M" won on the track team. He began electrical work early as a wireman for the Bartlett Illuminating Company of Saginaw, Mich., 1895-6, and then as assistant engineer for the Park & Boulevard Commission of Detroit in 1897. He then became outside superintendent for the Detroit Public Lighting Commission, 1898-1900. Then he made quite a change of occupation, becoming electrical engineer for Phelps, Dodge & Co., with great copper smelting plants at Morenci, Ariz., 1900-2. By this time his leading ideas as an inventor were well developed and in 1903 he became president of the Square D Company, a position held down to date. It was while he was still with the Public Lighting Commission that Mr. Horton enlisted in the U. S. Navy and was commissioned chief electrician of the

U. S. S. *Yosemite*, during the brief war with Spain in 1898.

Mr. Horton is a member of The Electrical Manufactures Club, American Society of Safety Engineers, the American Institute of Electrical Engineers, the Detroit Engineering Society, and the Detroit Board of Commerce. He is also a member of the Detroit Golf Club, the Detroit Athletic Club, the Detroit Yacht Club, the Detroit Masonic Country Club, and the Old Colony Club. This would all indicate a generous universality of tastes, but one of the chief interests in Mr. Horton's active life is farming, in which many engineers join him.

In the electrical field Mr. Horton is widely known as the inventor of the "Arkless" enclosed fuse and a positive mechanical indicator for it; an accurate indicating low capacity fuse the fusible element being put under tension by means of a current-carrying compression spring; the Square D safety electrical switch, and the Square D meter testing devices for public utility corporations.

SCHWEITZER & CONRAD, INC.

Schweitzer & Conrad, Inc., is an Illinois corporation, the successor of Schweitzer & Conrad, a partnership, organized by Mr. Edmund O. Schweitzer and Mr. Nicholas J. Conrad, in 1910. The partnership was formed to manufacture S&C extra high potential fuses, which were a joint invention of Mr. Schweitzer and Mr. Conrad. The principal office and factory is located at 4435 Ravenswood Avenue, Chicago, Ill., and the business now covers the manufacture of a complete line of high voltage protective and switching equipment, including high voltage fuses, lightning arresters, circuit breakers, primary cutouts, disconnecting switches, safety disconnecting switches, voltage detectors, special relays, choke coils, bus supports, pole top switches, all kinds of protective combinations and outdoor substations. S&C Fuses, the original product manufactured by Schweitzer & Conrad, Inc., were developed to meet the very urgent demand for a high voltage fuse, which could be depended upon to interrupt overloads and short circuits on systems with large generating capacity.

About 1905, the importance of such protecting potential transformers on systems of large capacity became very apparent. There were a great many cases where potential transformer fuses opened without cause, that is, without any trouble in the transformers or without any overload. This opening of the fuses resulted of course in the interruption of integrating wattmeters and therefore it was very annoying in billing large customers, such as electric railways, etc. In many cases, the operation of integrating wattmeters might be interrupted for hours and days at a time, before the interruption was noticed. This trouble of course was also very serious and costly because of the fact that it interfered with the operation of indicating instruments, such as voltmeters, wattmeters and synchroscopes.

A few years later, the vital question of potential transformer fuse protection was brought home very forcibly by a number of disastrous fuse failures, when the fuses were called upon to interrupt short circuits on systems of large capacity, and when these fuse failures resulted in very serious damage and interruption of the general service. In at least one instance, a fuse failure of this kind resulted in the wrecking of bus chambers, the throwing of bus bars off their insulator supports, and the breaking of windows throughout the building.

As a direct result of these fuse troubles, Messrs. Schweitzer and Conrad applied themselves to the development of a new and more reliable fuse; and the fuse now known as the "S&C Fuse" was the result. The fuse consists of a glass tube enclosing a spiral spring, which holds in tension a fuse element proper about one-half inch long and which is enclosed in a cork. The fuse is filled with a non-inflammable liquid of very high dielectric strength, which ex-

BRYSON D. HORTON

tinguishes the arc when the fuse operates. A funnel-shaped liquid director which is fastened to the spring just below the fuse element proper directs a stream of dielectric liquid on the moving terminal as the spring contracts and assists materially in the extinguishing of the arc. In the larger sizes of fuses, that is above 25 amperes capacity, no cork is used, but the fusible element is placed in a separate explosion chamber at the upper end of the fuse.

Although S&C Fuses were originally developed to protect potential transformers, this field is now of secondary importance. The fuses now are used very extensively for the protection of power transformers of all capacities. Fuses are regularly furnished up to 400 amperes capacity and for all voltages up to 115,000 volts.

Since the early development of S&C Fuses, Schweitzer & Conrad have specialized in the manufacture of protective and switching equipment. Most of the equipment manufactured by this company is novel and along entirely original lines. The company has done research and development work in connection with increased rupturing capacity of oil circuit breakers, lightning arresters, relays, and many other lines of protective and safety equipment. The result is that the company now manufactures a very complete line of protective and switching equipment, the novel features of which are protected by patents granted and pending in the United States and foreign countries. The equipment is sold and advertised under the trade name "S&C," and follows the tendency of the art toward higher standards.

STEINMETZ ELECTRIC MOTOR CORPORATION

In an article written in 1916 in the *Illustrated World,* Donald Wilhelm said of Dr. Charles P. Steinmetz: " 'If I were to report his work in the last twenty-five years,' explained a person authoritatively able to explain, 'I'd have to describe the best of all that has been done in all those years in perfecting street lighting, in making cheap car lighting and quick elevator service possible. He has made more plentiful nearly everything that's manufactured, besides perfecting the induction motor, the polyphase motor and other special motors.' " In brief addition to the above, it may be noted that there lies on the present writer's desk at the moment, the two circulars, one describing the Steinmetz engineering library of nine volumes, embodying the theory and practice of the physicist and mathematician, and the other his work in the development of the Steinmetz electrical trucks for commercial and industrial purposes. No better illustration could be offered than that of universal genius and a profound ability to solve engineering problems.

The Steinmetz Electric Motor Car Corporation is founded on the inventions of the "Sage of Schenectady" applied to the automobile art. An illustration of the Steinmetz truck as typical of the latest improvements and perfections in the field will be found in the chapter on the history of the electric automobile in this volume of the "Story of Electricity." The refined but sturdy nature of the truck can be readily inferred from the engraving, but a few details may be added from the general specification. The frame is of pressed steel channel, hot riveted. The drive is double reduction with bevel and spur gears running in oil bath; and the motor has a specially designed field and armature giving, it is claimed, unprecedented efficiency, series, compensated, fully enclosed and readily accessible. The rear axle is of notably unusual design, of pressed and cast steel, enclosing the motor and the gears. The motor has ball bearings, and gives its maximum performance under a wide range of operating conditions. The control furnishes a continuous torque, with four speeds ahead and two reverse, and the brakes are double expanding on the rear wheels. The front springs are semi-elliptic, 38 inch, and the rear semi-elliptic, made of alloy steel, insuring great strength, flexi-

bility and long life. The tires are pneumatic cord, straight side, 32 by 4, on all wheels. The storage batteries used are standard Exide, iron-clad or flat plate, and the accessories include three electric lights—two at the dash, and one tail; Hub odometer, Sangamo amperehour meter, switches, charging plug, necessary tools and fenders. The wheels are of standard artillery type. The weight of the half-ton type is 2,500 pounds, and that of the one-ton type is 3,000 pounds without body. A speed is obtainable of 18 miles an hour on hard, level surfaced roads.

Dr. Steinmetz himself, discussing the foremost features of his design, points out:

(1) The construction of the motor and its control, which has been specially designed so as to well maintain the speed on heavy upgrades and with heavy loads, to give a quicker and less sluggish get-away in starting, and to save all the power possible, thus increasing the mileage.

(2) The motor suspension and gearing, which is an improved type of that which has been so successfully used by the electric trolley car for over thirty years. It protects the motor and gearing from the shocks of the road, and gives a simpler and more compact, thus more reliable, power plant to the car.

(3) Lower weight of the car, due to the higher efficiency of every structural element of the car, resulting from the careful design of every element so as to give it maximum strength with minimum weight.

(4) Lower cost and corresponding low price, resulting from the above discussed features, and from the use as far as possible of standard parts throughout.

The Steinmetz Corporation is building its trucks of the commercial type for general delivery purposes, and its industrial trucks for use in freight houses, steamship piers and miscellaneous manufacturing plants. The corporation is organized under the laws of Maryland, and its factory plant is at Arlington, near Baltimore. Dr. Steinmetz is the chairman of the board of directors, which includes such well-known men as President Herbert A. Wagner of the Consolidated Gas Electric Light & Power Company of Baltimore, Md.; President W. F. Ham, of the Washington, D. C., Railway and Electric Company, and Vice-President A. J. Norton, of the Commercial Trust Company of New York, and Vice-President Victor Angerer, of the Taylor-Wharton Iron & Steel Company.

CHAPTER XVII

THE STORY OF ELECTRICITY IN IRON AND STEEL

As Exemplified in the Accomplishments of The Wellman-Seaver-Morgan Co., Cleveland, Ohio.

THE story of electricity in the iron and steel industry would be incomplete without a brief mention of the life and work of the late Samuel T. Wellman, who during his life once was characterized by Charles Schwab as the man who did more than any other living person in the modern development of steel.

Mr. Wellman was born in Wareham, Massachusetts in 1847, and received his early education in Nashua, New Hampshire. While at Norwich University where he was taking a course in engineering, there came the call for more volunteers in the Civil War, and cutting short his studies he rushed to the front, serving as corporal in the New Hampshire Artillery. Returning from the war he entered the employ of the Nashua Iron Works, and took charge of the construction of the first Siemens regenerator gas heating furnace put up in this country, built from drawings furnished by the Siemens' Company. The work was completed before the arrival of the Siemens' engineer, sent over to superintend the work, and it proved so satisfactory, that he became associated with Wellman in building many other furnaces, and, in particular, the first crucible steel furnace built in America, at the works of Anderson Cook & Company. The results obtained from this furnace were remarkable in that it was possible to melt a ton of steel with 1000 lbs. of nut coal at a cost of less than $1, where in the old type of coke furnaces there were required 3 tons of coke worth from $2 to $10 per ton. After constructing a number of other furnaces for the Chrome Steel Works, Bay State Iron Works and Nashua Iron Company, Mr. Wellman went to Cleveland, Ohio, to design and build the Otis Steel Works, where he remained for 18 years.

It was during this period that he developed two inventions which have become indispensable to the economical operation of open hearth steel works and which link his name throughout the world with the steel industry, namely: the *electro magnet* for handling the iron and steel, and the *charging machine* for charging open hearth furnaces. It is estimated that the annual saving today by the use of the electro-magnet amounts to $1,500,000 per year; while the savings by the use of the open hearth charging machine amounts to $10,000,000 per year.

Mr. Wellman was a man of indomitable will, unbounded enthusiasm and indefatigability in his work. His travels all over the world made him an interesting companion and his genial temperament brought him a host of friends. He was a life member and past president of the American Society of Mechanical Engineers, also a member of The American Institute of Mining Engineers, The British Iron and Steel Institute, The British Institution of Mechanical Engineers and the Cleveland Engineering Society, of which he was an honorary member and also a past president.

Mr. Wellman died in July, 1919, leav-

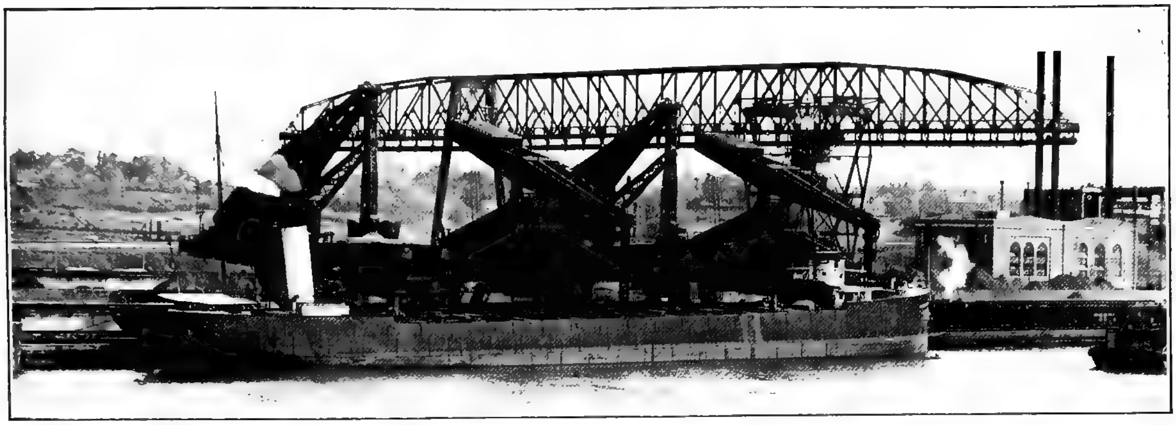
ing a name indelibly impressed, at home and abroad, on the annals of the engineering world.

The best known and most widely used of the Wellman-Seaver-Morgan products is the Wellman open-hearth charging machine, in use in all the steel producing countries of the world and constructed in a variety of types. Its motive power is the electric motor and for each of its movements it is fitted with an individual motor. The accompanying illustration shows a high type machine ready to charge the material into the furnace from which the molten steel will be tapped after the lapse of a few hours.

In metallurgical plants of every type, electric power is the medium used for the operation of all kinds of slab chargers, forging manipulators, mills, strippers, cranes and a host of other apparatus, all serving the one end—of relieving human labor of its severest tasks. Perhaps the most remarkable, as well as intensely interesting machine built by the Wellman-Seaver-Morgan Company, is the automatic electrically operated unloader, which on account of its size and its almost human operation, has revolutionized not only the methods of unloading bulk material from vessels, but also caused a complete change in the construction of the vessels devoted to the carrying of coal and ore on the Great Lakes, and at the present day, of ocean carriers. These machines are so intimately tied up with the development of the ore mines in Michigan and Wisconsin that a short history of the growth of the ore trade will be of interest.

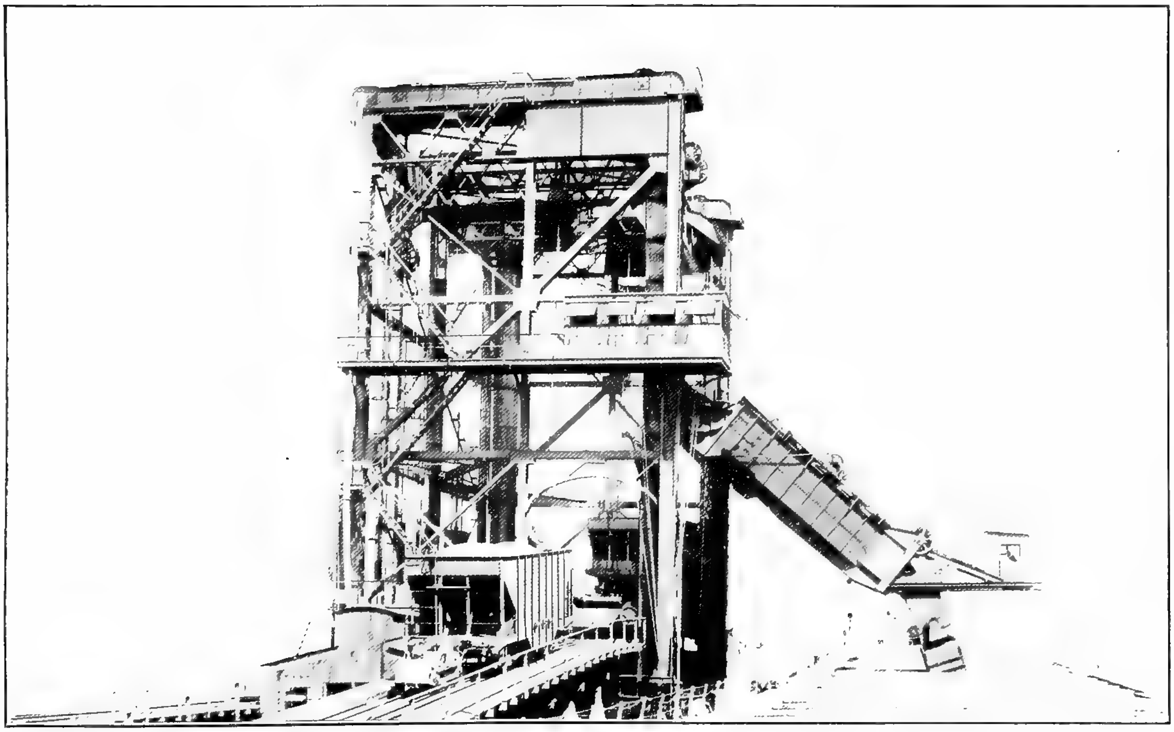
Wellman-Seaver-Morgan—High Type Open-Hearth Charging Machine in Operation

Commencing with the discovery of iron ore on the Upper Peninsula of Michigan in 1844, the shipment of ore increased from a few barrels of ore on the deck of a sailing vessel, which was unloaded and teamed around the rapids at Sault Ste.

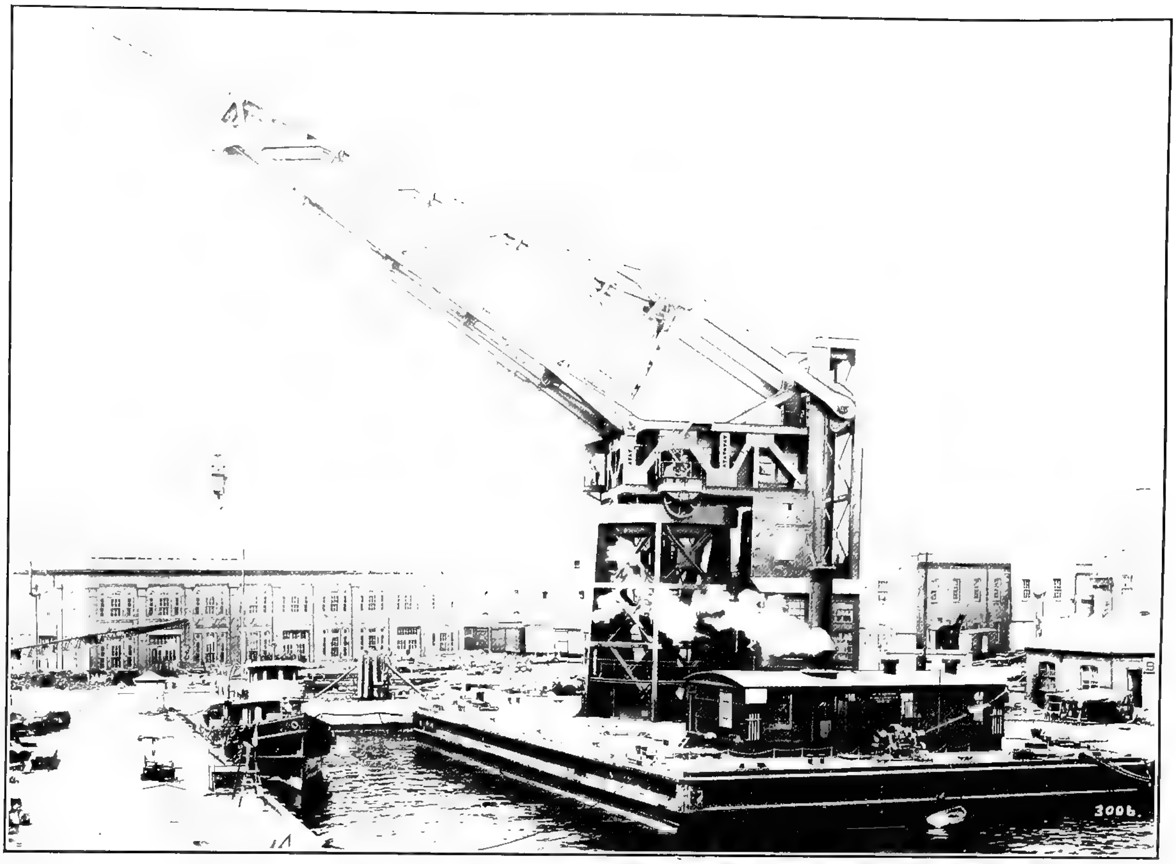


The above view shows the plant of the Ohio & Western Pennsylvania Dock Co., at Cleveland. Four 17-ton unloaders and a 15-ton bridge. *On July 2,1915, these machines, working in the Steamer "James A. Farrel," unloaded* 11,083 *tons in* 3 *hours and* 35 *minutes*

Marie, to 66,000,000 tons of ore in 1916, carried through the Soo Canal on an endless fleet of carriers, having cargoes up to 13,000 tons each. From the beginning until 1880, in which year 1,908,745 tons of ore were brought down, the ore was all shoveled into tubs which were hoisted to the decks of the vessels where they were dumped into wheel-barrows and wheeled to cars or stock pile on the dock. This method was replaced in 1881 by a cable way carrying a trolley from which was suspended a bucket that was hoisted direct from the hold of the boat and traveled and dumped into cars, or on stock pile as desired. This method was used until 1890. Up to this time the unit of bulk in uploading was a shovelful of ore weigh-

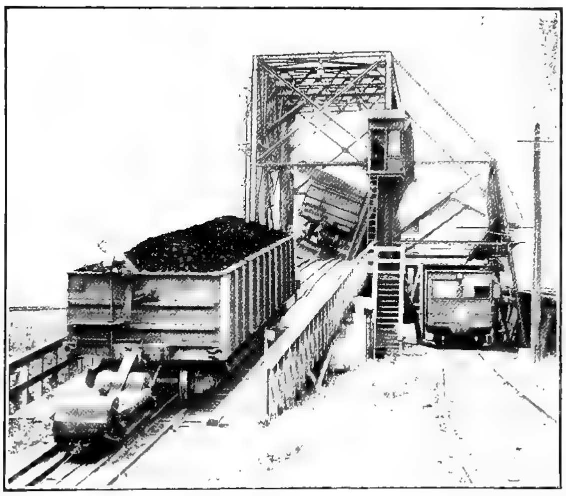


Wellman-Seaver-Morgan—Car Dumper

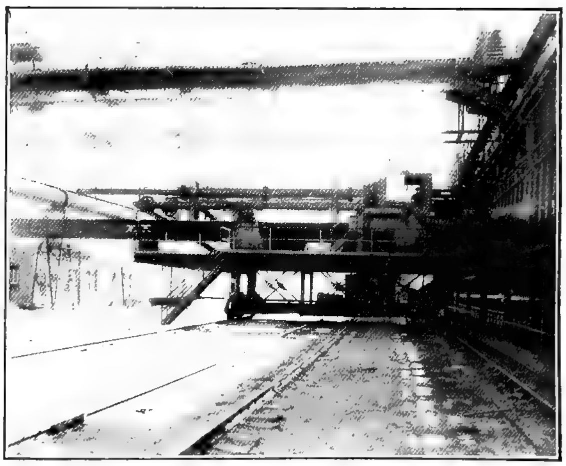


Wellman-Seaver-Morgan—Pontoon Crane, 150 tons Capacity

ing about 17½ pounds, and it was becoming evident that hand shoveling must be supplanted by other and more efficient means in order to handle the tremendously increasing tonnage of ore coming down the lakes. It remained for one farsighted man to suggest and carry out the daring idea of using a self-filling bucket of extraordinary large capacity. This man was Mr. George H. Hulett, who conceived and

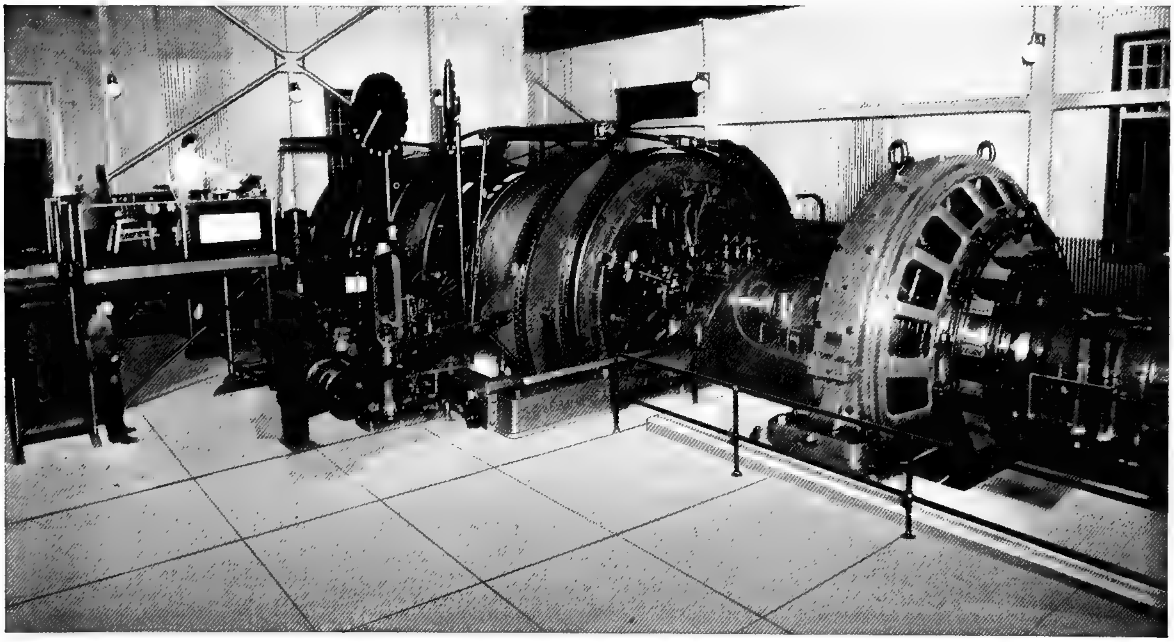


Wellman-Seaver-Morgan—Car Dumper



Wellman-Seaver-Morgan—Coke Pusher

successfully developed the large unloaders now so well known all over the world. Mr. Hulett had for a long time been active in developing equipment specially adapted to handle large quantities of material, and through his successful work had gained the confidence of dock and vesselmen. His plan was a radical departure from the accepted methods, but his conception was sound and the results have proved its correctness. The first machine built had a bucket of 10 tons capacity and was being transferred direct from vessels to cars by the unloader. Each of the various motions of the unloader is controlled by a separate motor, 250 volts direct current, and the control equipment is of the magnetic switch type throughout, having master controllers in the operator's cab, in bucket leg, and on the larry. These two operators are the only ones required for all of the functions of the machine. In addition there is an oiler for each machine.



Double Drum Direct-Connected Electric Hoist

steam and hydraulically operated. Although remarkably successful, the best results were obtained after the machines were operated electrically; and all machines are now built with motor drive. The capacities of these machines have been increased to 17 tons, and with four machines of this size, a 12,000-ton boat can be unloaded in less than 4 hours. The cost of unloading has been reduced from 19c per ton to 4½c per ton.

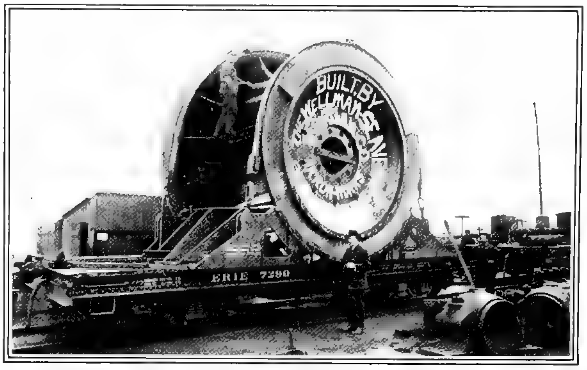
As shown by the accompanying cut, the usual equipment of a dock consists of four unloaders and one rehandling bridge for placing the ore in stock pile and removing from stock pile for re-shipment by rail, as much as possible of the ore

For handling the immense quantities of coal required in the Northwest, shipped in boats from the lower lake ports, the most effective machine is the electrically operated car dumper shown in the accompanying picture. This machine receives a car of coal as it comes from the railroad tracks, raises it and at the same time overturns it so that its contents flow out onto an apron and thence through a chute and a trimmer into the hold of the vessel. This machine is also used at steel plants and other mills for running ore or coal onto a stock pile.

In the development of the coke making industry, in which the by-product coke oven is rapidly replacing the bee-hive oven, the

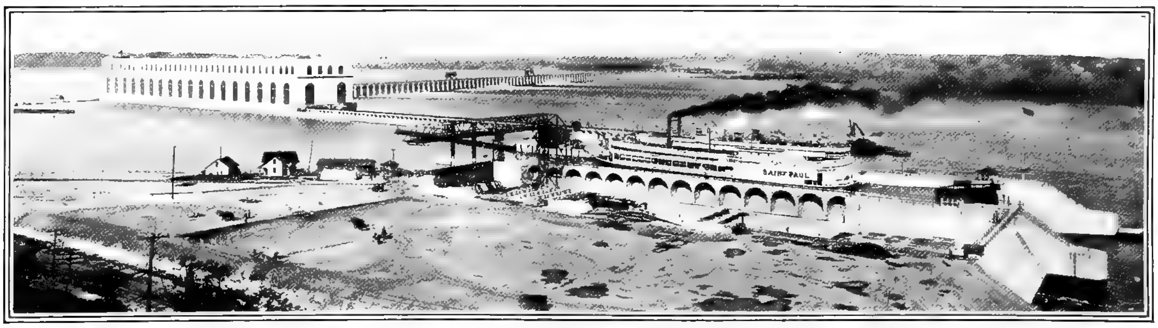
electric motor is applied to pusher, leveler, door extractor, quenching car, mudding car, etc. The illustration shows a combined pusher, leveler and door extractor as used in the largest coke oven plant in the world.

In our Navy, where the electric motor is finding constantly new applications, it serves as the motive power for the floating cranes which handle the heaviest loads to be placed on board a man-of-war. The massive structure shown in the accompanying illustration is a floating or pontoon crane of 150 tons capacity, the largest ever built in this country and soon to be followed by a still larger crane mounted upon a self-propelling vessel.



Hydraulic Turbine Runner Loaded on Specially Designed Car

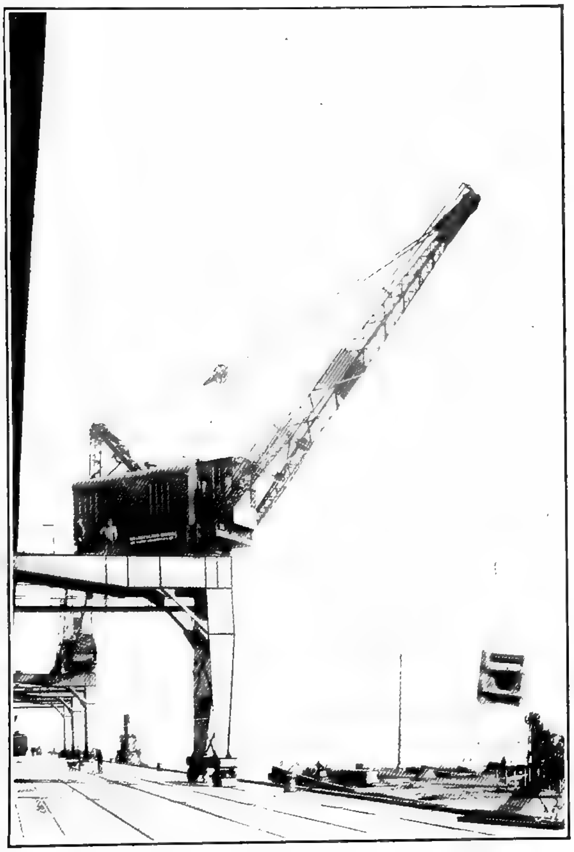
The application of electricity to mine hoist equipment has shown wonderful development since 1889, when the concern built its first electric hoist for the Thomson-Houston Electric Company. In the early days of the application of electricity to mining work, there was a certain amount of prejudice to be overcome, due to a feeling on the part of the operators that the new power was unreliable, and the unsatisfactory methods of control then available. The increased knowledge of electricity and the perfected system of controls have, however, entirely overcome these objections, so that to-day the Company is building electric hoists of sizes ranging from the room hoist, having a 10-in. diameter drum geared to a 3 h.p. motor with a simple starting switch, to the mine hoist having 12 feet diameter drums direct-connected to 1,850 h.p. motors with Ward Leonard control. The accompanying illustration shows a double-drum direct-connected hoist, which is one of the largest in this country as well as the most complete from an electrical standpoint. The total unbalanced load handled is 42,000 pounds hoisted from an ultimate depth of 4,000 feet to a maximum speed of 3,000 feet per minute. The drums are 12 feet diameter grooved for 1⅝-inch rope, and will hold 5,000 feet of rope in two layers. The electrical equipment consists of an 1,850 h.p. 71 r.p.m. 550 volt direct current motor, coupled direct to the drum shaft of the hoist and connected electrically to a generator of equivalent capacity, which is driven by a 1,400 h.p. 550 r.p.m. A. C. motor. Mounted between the motor and generator is a 100,000 pound flywheel which equalizes the peak loads in hoisting. Operating levers for controlling the hoist are grouped on a large elevated platform, and the control and reverse levers are sep-



General View of Power House, Dam and Government Lock at Keokuk, Iowa

SAMUEL T WELLMAN

arated but so interlocked that when the control lever is in the "on" position the reverse lever cannot be moved. The safety device also includes a mechanism for moving the control lever to the "off" position when the skip has reached a predetermined point, holding the lever in this position until the reverse lever has been moved to the opposite position, the operator being thereby prevented from starting in the wrong direction.



Four Wellman-Seaver-Morgan Semi-portal Bridge Type Dock Cranes at Boston Army Supply Base

To use the electric current it must be generated and the one inexhaustible source of supply is nature's "white coal" water power. To harness the many waterfalls in the world is probably the most important task to-day—in view of the necessity of conserving the fuel supply. The hydraulic turbine is becoming the world's greatest prime mover and among the foremost builders of equipment of this type this company has taken a leading position. While water will continue to flow over falls and through rapids forever, it is essential that when once directed on a wheel to develop power it should be used as efficiently as possible and herein lies the best service a manufacturer can offer.

One of the Company's large and unique installations is the plant located on the Missisippi River at Keokuk, Iowa, which has the distinction of being by far the largest water power development in the world, at present being completed for one-half of the ultimate turbine installation and the superstructure for the other half being partly finished. The complete power house will be about 1,800 feet long and will contain 30-10,000 h.p. main units and four 2,200 h.p. auxiliary alternators or exciter units. The normal head on the turbine is 32 feet, the maximum head being 39 feet and the minimum 20 feet. The turbines cover this range of head at a constant speed of 57.7 r.p.m., the output varying from 6,000 h.p. at 20 feet to 15,000 h.p. at 39 feet. The nominal rating of 10,000 h.p. is at 32 feet.

At the time these wheels were constructed, they were the largest wheels in existence. The runners are 16 feet 7 inches in diameter and weigh 130,000 pounds each, being the largest single casting of this nature ever made. The main generators are 3 phase, 25 cycle, 9,000 k.v.a. 11,000 volt. They are 31 feet 5 inches outside diameter and 11 feet 3 inches in the center.

This company has built the two largest hydraulic turbine units in the world. Each unit develops a maximum of 60,000 h.p. under a head of 305 feet at a speed of 187.5 r.p.m. These units are installed in the new power plant of the Hydro-Electric Power Commission of Ontario, in their new Niagara Plant referred to in the chapter on electrical development in the Dominion.

CHAPTER XVIII

DISTINCTIVE PIONEERS IN VARIOUS LINES OF ELECTRICAL MANUFACTURING

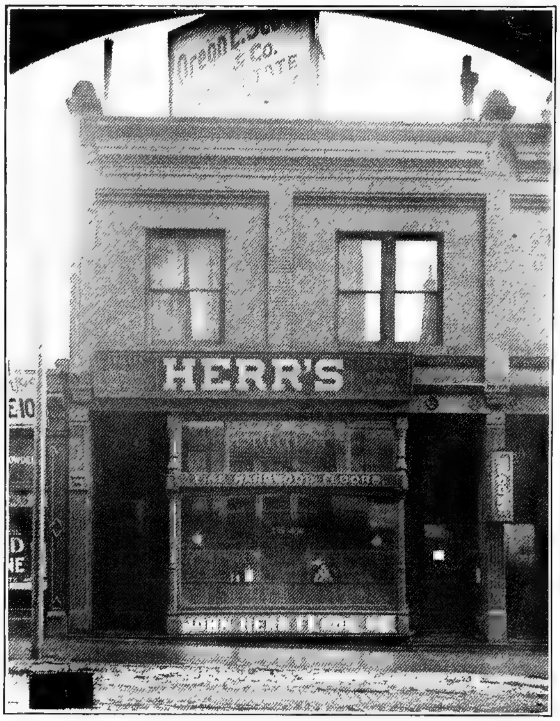
WAGNER ELECTRIC MANUFACTURING COMPANY

VERY distinctive pioneership over a period of full thirty years stands to the credit of the Wagner Electric Manufacturing Company, one of the foremost productive institutions of St. Louis, and one that is in a large measure contributive to the forces that have made the city strategic and dominant as a point of distribution and trade. With equal steps the company has matched the expansion of the great electrical industry in which it is a leader. Although its range of output is far beyond the ordinary, it has always specialized in distinctive fields, ever since, in 1890, Messrs. H. A. Wagner and F. C. Schwedtmann established the enterprise as a modest private partnership, first to make fan motors for alternating current circuits and later, ambitiously, to build a new form of power motor then badly needed, the single phase. These young engineers as Superintendent and Chief Engineer were operating the large pioneer alternating current system of the Missouri Electric Light & Power Company in St. Louis, whose urgent needs for better transformers soon invited the inventive energies of the firm, and led to the formation in 1891 of the Wagner Electric Manufacturing Company, with an initial capitalization of but $25,000. Up to 1893 the products of the concern were alternating and direct current fan motors and transformers of small size; and the actual commercial single-phase motor development did not come until 1897. Meantime, in 1892, Mr. W. A. Layman, fresh from Rose Polytechnic Institute, had joined the growing organization, of which later, after passing through all the grades from draftsman and foreman, he was to become President. Between 1894 and 1900, the company launched out into considerable work as a builder of direct current motors and switchboards; but, for many years after, the Wagner name earned its reputation very largely in the development of the modern transformer art. The central station as a public utility was at the height of activity, and its demand for reliable and ever larger transformers seemed to be beyond satisfaction. The Wagner manufacturing plants grew with incredible rapidity, as each new opportunity presented itself and was met. In the same period, 1895–1900, the company had also launched out extensively into the manufacture of generators; and, in 1896, a notably successful line of alternating current switchboard meters was put on the market. All of this called for new buildings, and added floors to the existing ones.

It is fitting at this stage of the narrative to mention some of notable historical work done by the Wagner shops in the advance of the transformer art, especially as engineers came to realize that important as might be the function of the transformer as an instrument in distribution,

an even more vital necessity for it had arisen in meeting the new possibilities of hydro-electric transmission. When transformers were proposed for a line from Riverside to Redlands, California, to handle energy at 10,000 volts, many well-informed persons looked askance at the plan, but the Wagner Company undertook to build such transformers, and their boldness was rewarded with instant success. Those transformers operated without trouble of any kind for over twenty years, until finally replaced by units of larger capacity. Still higher voltages were soon visualized as feasible, and once again the Wagner Company pioneered and built 40,000-volt power transformers, the first ever seen. These even now remain in useful service. Next came a long step in the direction of larger units. Consequent upon the development of the big hydro-electric plants at Niagara Falls, transformers were needed to deal with current in correspondingly larger volume for new and novel industries, and, about 1896, the Wagner Company undertook to build the first 1500-kilowatt transformers, and forthwith produced seven of them, some of which again, remain to this day in effective operation. In the prosecution of this work, the company was conspicuous by its early adoption of silicon steel laminations to reduce eddy currents and hysteresis losses in the magnetic circuit, and it even imported such material before the production of it in America. The Wagner power transformers, oil filled, self cooled or water cooled, are typical standards of excellence in this field.

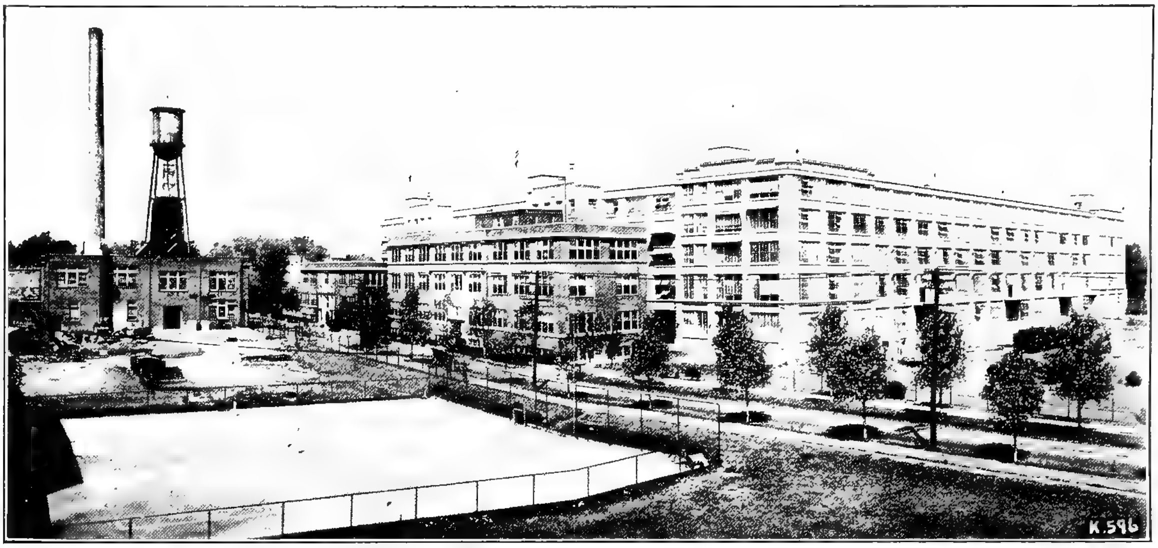
Returning for a moment to the facilities of the company, it may now be recorded that while it was still in its infancy the first factory in a small store building at 1822 Olive Street was soon found inadequate, and it has long since disappeared in the western march of the business district of the city. A new site was secured in 1892, and a three-story building erected and occupied in the fall of that year. Story after story was added, until there were seven. Other buildings were erected, but again the growth of the concern compelled another removal from what is now known as Plant No. 2. Once more a new site was acquired, at 640 Plymouth Avenue, on the inner Belt Line of the St. Louis Terminal Association and the main line of the Wabash Railroad. In 1907 the older buildings of this Plant No. 1 were completed, offices were installed, and various manufacturing departments moved or inaugurated in the seven large buildings that had been erected. Constant and steady growth was sustained and around the original nucleus other large, new factory buildings were added, practically at the rate of one every year for the period 1910–1917. During the Great War, when the plant became



1822 Olive Street, St. Louis, the Site of the First Wagner Factory. Early in 1890.

an extensive munitions producer, the company also established an 8-inch howitzer shell plant at Maple Avenue and the Wabash tracks, used until its necessity ceased at the end of 1918. For shell purposes also, the company built two large parallel buildings, united by connection at one end, each 512 feet long and 50 feet

wide. This building, virtually 1100 feet long, was taken over from the U. S. Government by the Wagner Company, the shell-making machinery was removed, and it was replaced by tools and machinery suitable for the production of medium size motors, approximating ¾ h.p. to 2 h.p. —a welcome addition to the facilities of the company when the "piping times of peace" should come around again. As a matter of fact, another auxiliary known as Plant No. 5 was also established at the struggle grew in intensity, a lavish use was made of them, and a destroyer would sometimes throw out as many as 15 or 20 in a single attack, so that "it can be truthfully said that the death knell of the German submarine had the ring of Wagner Quality in it." Another distinctive line of work was covered in a gun plant erected by the R. & V. Wagner Ordnance Company, which, under a contract calling for about 15 per cent of the total number of Navy 4-inch guns required by the



Plant No. 1, Wagner Electric Manufacturing Company, from Southeast

Cass Avenue and Thirteenth Street, where certain small manufacturing operations could be carried on to advantage. It will be seen from this brief summary that the company enjoys the command of splendid shops, centrally located from the geographical point of view, and as regards ability for easy and prompt shipment in any direction.

Only brief reference can here be made to the large part played by the Wagner Company in war work. Within a couple of months of the fateful April 6, 1917, the company was furnished with blueprints for depth bombs for the fight against the submarine; and very soon it had supplied several thousand bombs. As Government, actually supplied about 70 per cent of the total of all deliveries. This plant became one of the most famous in the country owing to its wide and successful employment of women. Accidentally, the Wagner Company learned that the War Department was having trouble getting steel hubs for 56-inch artillery wheels. Two suppliers of forgings were located, and the Wagner Company took on the entire job, while later the quantity was practically doubled. During 1915–16 the company was highly successful in the manufacture of 8-inch shells for the British Government; and this led logically to similar production for the U. S. Government, although the

American type differed from the British in design and construction, and followed French practice. No fewer than 85,000 inch shells were delivered to the British without a single rejection on firing test; and the company also contracted for 170,000 American type 8-inchers and 300,000 of the 155 mm. type, employing 1500 men on the two types. Moreover, a large number of "dummy" cartridges were made for the Navy in 3-inch and 4-inch sizes, used extensively in loading practice by the jackies. Yet another device made in large quantities was a detonating fuse for Russian shells, of which under three separate contracts some 800,000 fuses were turned out for American corporations making Russian shells. These detonators had 18 individual parts, embodying the highest quality of machine shop work, but the company received a high compliment from the Imperial inspection staff on the excellence of the whole output. In turn, upon our own entry into the war, this brought a telegraphic request from the U. S. War Department to reserve the Wagner facilities for a similar device adapted from French practice, the production of which attained a daily maximum of 15,000. There were also such incidental products as the 3-inch gun mounts and the one-pounder guns. It need not be wondered at that in January, 1918, the company found itself committed to a production record for the ensuing year four times that of its maximum peace record. And then came peace!

The present and future history of the company lies in reversing such figures as it swings away from the huge tasks reluctantly but successfully assumed during the war and bends all its energies to peace activities. It will be remembered that the Wagner reputation was based at first on its introduction of the successful single-phase motor of the repulsion-starting, induction-running type. To this has been added the compensated type, which is compensated in the larger sizes to take leading current from the line—a great advantage to the central station near the limit of its line capacity. Another later line of the Wagner Company is that of polyphase motors, which start full load and rapidly attain full speed, after which the speed is constant. These, like the single phase, are well adapted to automatic or remote control.

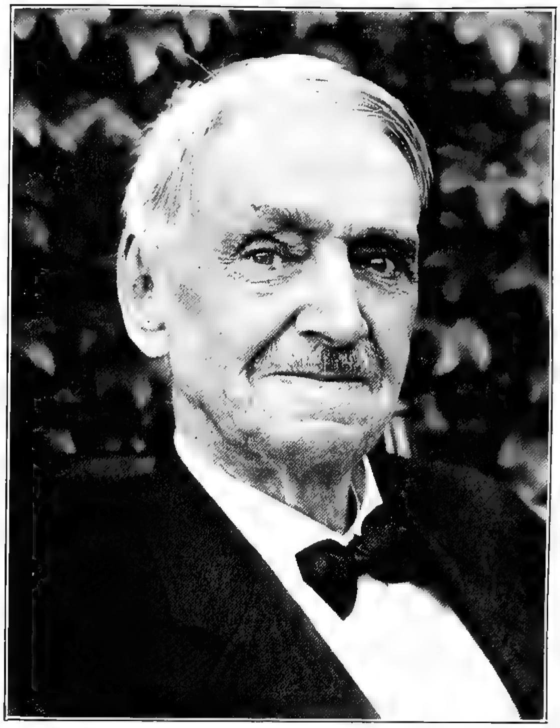
Other large branches of Wagner production today are represented in single-phase and polyphase converters for a wide range of use such as vehicle battery charging, motion picture projection arcs, charging low voltage storage batteries for ignition work on automobiles, motor boats, etc. Of analogous nature are the Wagner rectifiers. Additional to all this, however, is the manufacture by the company on a very large scale of automobile engine starters and ignition systems, and electric automobile motors. Such appliances are built specially for the make of automobiles they are to equip.

Quite apart from all this, but in a field where they have won also an unsurpassed reputation, are two large and distinct lines of switchboard instruments and portable instruments. The company was first in the market with the now universal alternating current edgewise type meters, and the first "dead-beat" and illuminated dial alternating type of instruments made are also to be credited to the same progressive source of origin. Supplementing these also are lines of Wagner portable instruments, used extensively in college laboratories and manufacturing test departments, as well as those designed specially for the use of the "trouble shooter." In all these, temperature errors have been reduced to the lowest practical minimum. Alternating current instruments of the Wagner make tested by the U. S. Bureau of Standards have been found free from wave form and frequency errors, for all commercial practice.

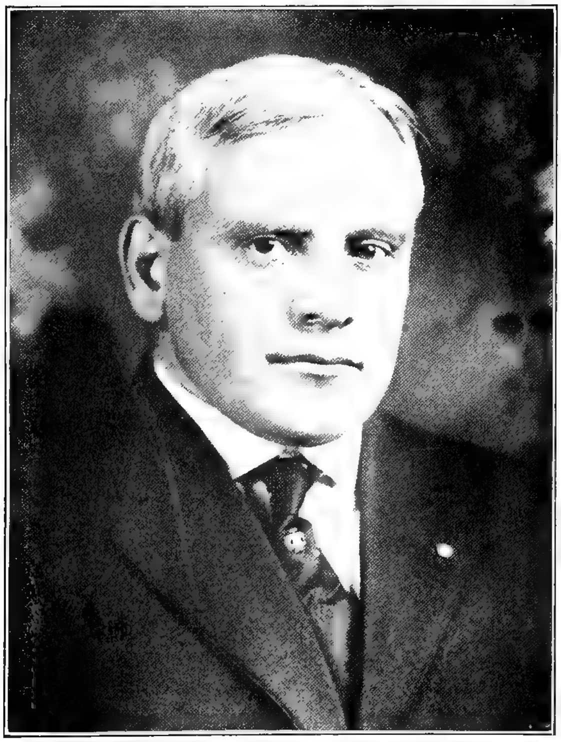
The Wagner Company, in addition to its executive and administrative forces concentrated at St. Louis, has large branches in all the leading cities of America, and offices and representatives in Montreal and Toronto, and in London, England.

The accompanying page of officials, past and present, and the sketch and illustration of Mr. Layman will be of interest.

The Late S. M. DODD, ex-President



The Late JAMES M. BELL, ex-Vice-President



W. S. THOMAS, Vice-President and Treasurer

A. H. TIMMERMAN, Vice-President and Chief Engineer

Born at Smithton, Mo., Oct. 27, 1869, and raised in Indiana, Mr. W. A. Layman was graduated from Terre Haute, Ind., High School in 1881 and from Rose Polytechnic Institute at Terre Haute with degree of B.S. in Electrical Engineering. In 1894 he received the degree of M.S., upon presentation of a special thesis; and in 1899 the degree of E.E. from Rose Polytechnic Institute. While in high school and in the University, Mr. Layman was very active in newspaper work, having on his own initiative established a monthly high school publication. This resulted in his being invited to join the editorial staff of the Terre Haute "Daily Express" during the summer vacation between his junior and senior High School year. After his graduation he became assistant editor of the same paper and later became editor of the Terre Haute "Saturday Evening Mail." Thus, for three and a half years during his college course, Mr. Layman paid his way through college by means of newspaper work.

In addition to this he was very active in college athletics, having been a member of the Rose baseball team during his entire University course. He was also a member of the Rose Track Team, and for two years held the Indiana 100-yard dash College championship; and both standing and running high jumps for three years.

Mr. Layman has been an active alumnus of Rose since his graduation and has been of great assistance to the University.

He entered the service of the Wagner Company, of which he is now President, in September, 1892, as utility man in the testing and drafting work; and made all the drawings for the company's first line of transformers and direct current motors. He immediately became identified with all the work leading up to the development of a successful form of single phase motor. He became Assistant Superintendent of the company in 1894; Assistant General Manager in 1898; Treasurer in 1900; General Manager and Treasurer in 1902, which position he filled continuously until 1908, when he was made Vice-President and General Manager. He was chosen President and General Manager in January, 1912, serving also as Chairman of the Board of Directors.

Mr. Layman has been in active management of all branches of the business since 1902, since which time his engineering achievements for the company have consisted mainly in passing judgment on detailed engineering work and looking up new lines of engineering and development work for the company; in addition to which he was in full active direction of all

W. A. LAYMAN
President

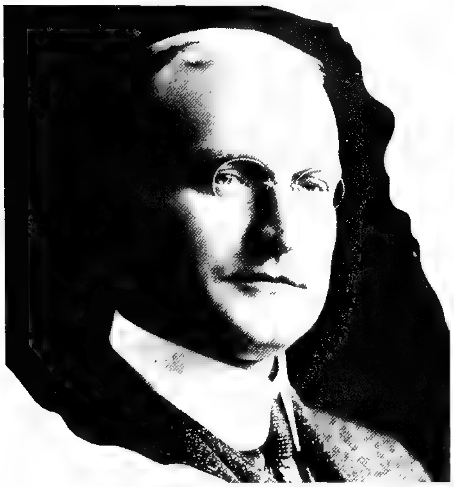
financial, commercial and manufacturing details of the company's business. The present organization is practically all of Mr. Layman's selection.

Mr. Layman was married in 1896 to Laura E. Toms, and they have four daughters: Edith (Mrs. Edward F. Deacon), Laura Arnold, Mary Arnold, and Grace Wilson Layman. Mr. Layman's interests and activities aside from the Wagner Company are indicated by the following: Fellow of the American Institute of Electrical Engineers; Associate Member of the British Institution of Elec-

trical Engineers; Past President, Engineers' Club of St. Louis; Past President, National Metal Trades Assn.; Member of Advisory Board of David Rankin, Jr., School of Mechanical Trades, St. Louis, Mo.; Member of the Corporation Board of Washington University, St. Louis; Member of the Board of St. Louis Union Trust Co., also the First National Bank in St. Louis; Member of the General Council, National Society for Vocational Education, New York. He is also a member of the following clubs: St. Louis, Noonday, Commercial, St. Louis Country, Bellerive Country, Contemporary, Town and Gown, and the Round Table.

THE STORY OF DELCO–LIGHT

The idea that finally became Delco-Light undoubtedly had its origin more years ago than anybody who just thinks casually about the matter would ever imagine.



E. A. DEEDS

This idea, it is generally conceded, was born of other ideas that can trace their existence back to the early lives of two men—E. A. Deeds and C. F. Kettering, who called into being Delco-Light, product of the Delco-Light Company, of Dayton, Ohio, one of the newest units of the General Motors Corporation.

Spending their boyhood days on farms in eastern Ohio, a few counties removed from each other, the boys, Deeds and Kettering, accumulated a store of firsthand experiences with country life as it was lived three or four decades ago on the eastern borders of our great middle-western farming belt. These experiences were those common to all folks who have lived and worked on the farms of America—and endured the old hardships of country and farm homes.

When they developed Delco Starting, Lighting and Ignition for automobiles and built their big factory at Dayton, Ohio, they took a considerable step toward the

C. F. KETTERING

goal which they reached finally in Delco-Light. With Delco lighting for automobiles they already had an electric light plant, portable, it is true, and a miniature outfit, but an outfit that suggested possi-

bilities far beyond the service it rendered in the automotive field.

Men associated with the Delco organization of earlier days tell of a man at a Florida camp who once wired for a separate Delco automobile lighting outfit, giving no explanation as to why he needed a whole new lighting system. When the service man from Dayton arrived at the Florida place with a trunk full of parts

R. H. GRANT
General Manager

and visions of a wreck or similar disaster that had put the man's car clear out of commission, he found that the owner of the camp had been lighting it by carrying lights into the house, on an extension cord from the Delco system on the car, and that he hadn't had any wreck at all.

It worked very well, the owner explained, except when they had to use the car after night, thus leaving the camp in the dark. They merely wanted the extra Delco set to light the camp.

"Right here," says Mr. Kettering, commenting on the incident, "we decided that if folks wanted house-lighting plants as badly as that we'd just proceed to furnish them."

So they started—not to building Delco-Light—bless you, no! To experimenting with farm lighting problems and to the gradual development of what was finally to become the world's greatest farm electric plant — and of course they called it Delco-Light.

It was during this experimental period of three or four years that the influence of those boyhood years on Ohio farms was called upon to help these men, Deeds and Kettering, to determine what kind of electric plant they were going to build.

"What kind of electric outfit would we have liked to have in the old days back there on the farm?" That was the question they kept before themselves.

Meanwhile, on the farms of their friends around Dayton and elsewhere they were conducting experiments with various sorts of home-lighting apparatus, constantly checking, observing and correcting until certain fundamental features were manifest.

First, they decided, Delco-Light must be a battery-charging plant. No farmer wants to depend on having his plant run every time he needs electricity. If anything goes wrong—and he's miles from a repairman, he's out of light—and power, unless there's a storage battery with electricity in reserve. So Delco-Light must have a storage battery. Settling this point settled another, the voltage. The earliest Delco-Light plants were of 32 volts. "Only sixteen cells needed and a lower priced battery," was the explanation. Later demands that arose, with the

Modern Comfort in the Country Home

growth and spread of the electric plant idea have called for Delco-Light plants with higher voltages, 65 and 110, and these have been produced in considerable number. But the plants that have been so generously adopted by farmers and have made the name Delco-Light a household word in over 160,000 homes are the low voltage, battery-charging plants.

Another point early settled upon was that the Delco-Light engine and generator must be direct-connected. This was for the sake of greater compactness in the outfit and for the greater efficiency that could be secured where engine and generator turned upon the same main shaft. Because of slipping, stretching, or breaking, the belt that ordinarily connected the farm gas engine to the generator, was a source of lowered generating efficiency, as well as of annoyance to the lighting plant owner.

Direct connection of the Delco-Light engine and generator were achieved by mounting the armature of the generator in front of the engine, upon an extension of the crankshaft. Here came up the question of bearings, and the builders of Delco-Light solved it by the adoption of bearings of highest merit. Delco-Light makers had long before settled that their Light engine was to be strictly high-grade. They scoffed at the idea advanced that the high-grade product they had planned was too high grade for farm service, and they did not fail to incorporate features which they had already assured themselves would mean longer life and fuller service than it would have without them.

A moment ago reference was made to bearings. Now, natural impulse and ordinary practice would call for three or four bearings on that main shaft, the crankshaft that supports the engine and generator. But this was to be an engine that would render unusual service and an engine that would evidence some striking examples of advanced engineering practice.

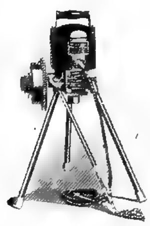
"Two supporting bearings for the crankshaft," was the decision. "You can get two holes in a straight line easier than you can three," said their engineers, so "two bearings" it was. A Hyatt roller bearing was used just behind the crankshaft throw and a New Departure ball bearing in front of it. Behind the roller bearing is the heavy flywheel and this is balanced by the armature on the front end of the crankshaft. Besides reducing friction and increasing the efficiency of the Delco-Light engine, this arrangement has simplified the problem of lubrication. The bottom of the crank case is the oil reservoir. A toothed wheel revolving in this throws a mist of oil over all working parts. This takes care of all lubrication for the plant; and "Only one place to oil" was another means their engineers took to eliminate trouble and annoyance for the folks who were to use Delco-Light.

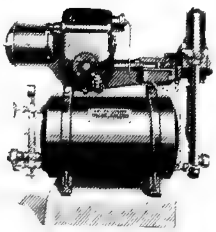
A conclusion reached at an early stage of Delco-Light development was that the engine must be air-cooled so that Delco-Light owners would be free from the annoyance and extra attention incident to running a water-cooled gas engine. With Delco-Light, a metal draft tube surrounds the single, finned cylinder; and the flywheel, mounted on the back end of the crankshaft, is equipped with blades, making it a fan. Turning at about 1,200 r.p.m., it draws the cooling air in great volume down over the engine and back through the generator, maintaining a good working temperature for all parts. This matter of temperature is an important factor as regards the fuel proposition, but more of that a little later. The point to

The Farm Water System can be Electrically Operated

be made right here is that Delco-Light is successfully air-cooled, a feature that will be appreciated most by those who have experienced the troubles incident to water cooling for the gas engine, freezing, steaming and boiling dry.

The question of fuel had to be disposed of, as it must be whenever internal combustion engines are under consideration. Kerosene, it was recognized, ought to be the fuel if it could be made to perform properly. The problem of adapting kerosene, it was declared, was not one of carburetion, but of combustion. Hence there is found one of the simplest of mixing valves in the Delco-Light fuel line. With it goes a combustion chamber properly designed for kerosene combustion—it works as well for gasoline, distillate or gas—and thus there is the higher temperature, possible because Delco-Light is air-cooled.

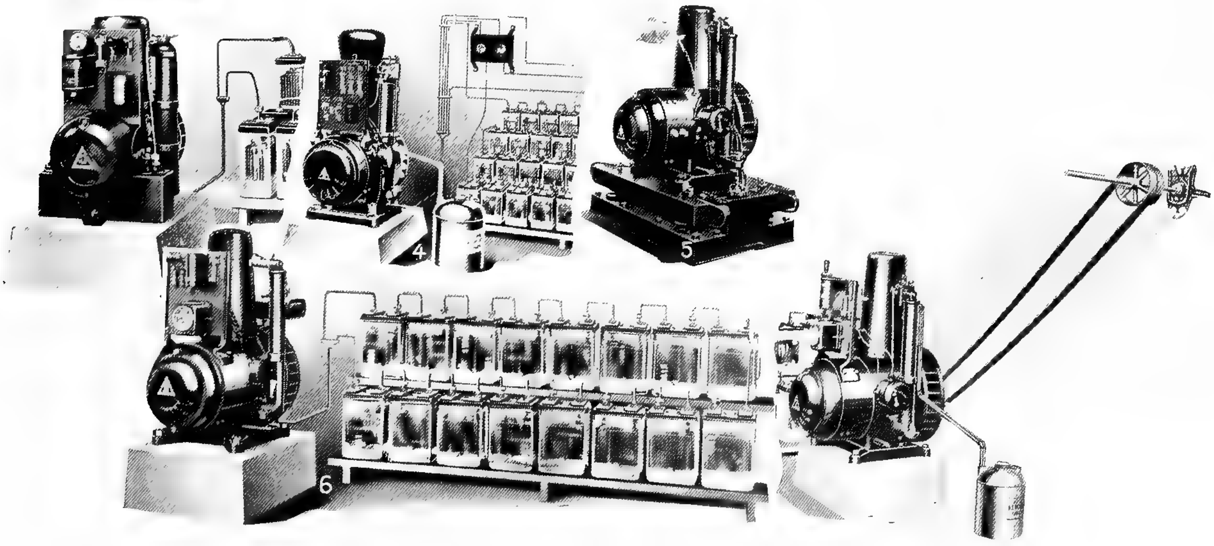




The water-cooled gas engine is supposed to work efficiently only below 212°, the boiling point of water. The air-cooled engine, of course, can operate, and does, several degrees higher, at a temperature where kerosene gas can be exploded with eminently successful results. So that the air-cooled Delco-Light engine is one of highest efficiency because, among other features, it burns kerosene for fuel at a temperature affording proper combustion.

Ever following the idea of high efficiency, never sacrificing it, however, to that other idea of convenience and practical service to the farmer owner, the company's engineers finally evolved Delco-Light, with its engine air-cooled, fitted, of course, with a Delco starting and ignition system, a single cylindered, four cycle engine, of the famous valve-in-head type, and with every other part, generator, switchboard and storage battery designed and built to a standard as high as that set for the engine. The result has been a plant, in different sizes, it is true and of occasionally varying characteristics, but always with the essential Delco-Light features, "true to type," a plant that will deliver from four to five kilowatts of electricity in regular service, from a single gallon of kerosene for fuel, and a half pint of motor oil.

Perhaps a word about the Delco-Light storage battery would not be amiss. Delco-Light storage batteries have all been made by the Electric Storage Battery Company of Philadelphia, the largest stor-



Various Standard Delco-Light Products

age battery company on the American continent. They are made from designs worked out by their own engineers and those of the Delco-Light Company, with special reference to the service they were to render in conjunction with the Delco-Light generating unit. This battery offers some very valuable features in storage battery construction. The cells are of clear glass, with sealed rubber covers. The battery plates are made unusually thick and heavy and, in addition to the usual wood separators, sheets of perforated rubber are also used, thus insuring perfect insulation and long life. The elements are suspended in the electrolyte, not supported on bridges at the bottom. This leaves a large free space at the bottom of the cell, so large that no piling up of material beneath the plates could ever cause short circuiting.

As it became apparent that Delco-Light was about ready to be offered to the world, the very important question of sales and distribution had to be cared for. R. H. Grant was the man to whom this considerable job was given, and at once he set about the building up of his sales force.

His factory was a part of the Delco factory for making automobile starting, lighting and ignition equipment, at Dayton, Ohio, and a factory force, recruited in part from the force of the parent company, skilled and competent workmen, began the production of Delco-Light. This was in the spring of 1916.

In pursuance of his organization plans, some fifty distributing districts were laid out in the United States and Canada. Selling organizations were formed, too, in most foreign lands except those of the European war zone; and before long, electricity from Delco-Light began to shine out, not only in the farm homes of our own land but in some of the most remote, unlooked-for places in the world. Ray Chapman Andrews, a noted explorer, recently told an interesting story of encountering Delco-Light in a Buddhist temple in the heart of Mongolia, away in the interior of Asia, at an almost inaccessible spot, where white men are rarely found.

The strong selling force of Delco-Light dealers, coupled with a great, comprehensive advertising campaign has been responsible, in great measure, for the rapid introduction and spread of Delco-Light. An ideal of this company has always been to have a trained, enthusiastic Delco-Light dealer in every agricultural county, or similar area in this and other countries; and the present Delco-Light selling force approaches this ideal more nearly than a great many people appreciate. Members of Delco-Light field organizations, dealers, servicemen and so on today will number well into the thousands, while more than 160,000 Delco-Light plants have been put into service since that day in April, 1916, when the first commercial plant was shipped.

The training of this Delco-Light force has been no small part of Mr. Grant's plan for selling Delco-Light. One of his dearest ideals,—shared you may be sure by those who dreamed first of Delco-Light, Messrs. Deeds and Kettering,—one of the highest ideals, has been to have a vast army of satisfied users of Delco-Light. And it has come to pass that the well-known slogan, "There's a Satisfied Delco-Light User Near You," is far from being an empty phrase. Users of Delco-Light who sometimes receive letters on the company letterhead bearing the above slogan are apt to return them with the notation, "That's me," "I'm him," "There are five of us in this very neighborhood," or some similar, gratifying commentary.

"Satisfied users," declares R. H. Grant, "are a natural result of a superior product and thoughtful, intelligent selling methods. The men who have been selling Delco-Light are responsible, in considerable measure for its success."

These men have been trained in numerous conventions, held at the factory at Dayton, and at the various district headquarters. These are continually being supplemented by sales schools and service schools, also held at the factory and in the field, with the result that there is an army of skilled men handling Delco-Light, men who are always on the job to insure Delco-Light users' receiving the complete satisfactory service which, as such users, they are entitled to receive.

Uses for Delco-Light have multiplied surprisingly since its inception as a farm lighting plant. Of course its most exten-

sive service is rendered to farm homes, but its value has been firmly established, as well, in a great many other fields. For motion picture shows and in rural community work it is rendering splendid service. Motor boats are equipped with Delco-Light for electric service. Garages use it for storage battery charging, for lighting, of course, and for running lathes and other small machines. Schools and churches are lighted with Delco-Light. In the oil fields regular and special Delco-Light models are in wide use. Summer homes, cottages, camps, hotels and resorts all are served with Delco-Light plants of proper types and capacities, as also are whole villages. Municipal lighting plants built up of Delco-Light units are becoming fairly common.

What about possibilities for further Delco-Light development? They are as far-reaching as those of electricity itself. For, wherever there is demand for electricity, there is a place for Delco-Light. A Delco-Light Water System, to operate with Delco-Light has been one of the later developments. This is a pressure unit, as compact and efficient as Delco-Light itself. It gives the country dweller the benefits of a modern water system along with electricity, and so rounds out the array of comforts and conveniences that are possible in modern country homes.

Another interesting piece of household equipment lately added to the line of Delco-Light products is Frigidaire, an electric refrigerator. This is really a cold storage plant brought down to household size. It freezes ice cubes or deserts for table use in one compartment, and keeps foods at a temperature slightly above freezing in another. It is made to be used in cities, with the various voltages encountered there, or with certain sizes of Delco-Light plant.

Still another, newer Delco-Light product is the Delco-Light Washing Machine, an electric washer which has been developed by Delco-Light engineers and which exhibits some features that are very different from those of the ordinary electric washer.

For instance, instead of employing a single, good-sized motor, with the customary train of gears, gear shift, clutch and wringer lock, the Delco-Light Washer uses two smaller motors, one for the tub and one for the wringer. These are reversible type, vertical motors, direct-connected to tub and wringer, respectively, with a simple gear and worm drive. The tub motor reverses automatically, giving the tub its rocking motion. The movement of the wringer motor, of course, is controlled by a switch, right on the motor itself.

An interesting feature of the development of the Delco-Light Washer is the use of a form of Photometer, to check the various steps in improvement in the washing action. The result has been a washing machine with exceptional washing ability, as proved unmistakably by Photometer tests, which measure accurately the dirt removed from white clothes, by recording the light reflected, on a finely graduated scale.

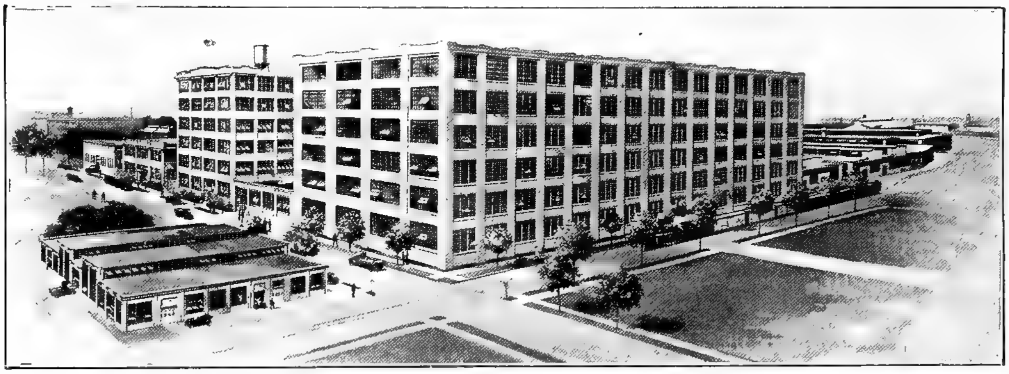
The Delco-Light Washer has been made, not only to be used with Delco-

A Common Example of Delco-Light Saving

Light, by owners of these electric plants, but is offered, in alternating current, to city dwellers also.

The Delco-Light factory at Dayton, Ohio, has made tremendous growth since the days of its beginning in a corner of the Delco plant. It kept crowding and encroaching on the space of the parent com-

pany until, presently, it was forced to seek quarters of its own outside. In the fall of 1917, the factory departments were moved into new quarters on a site the company had purchased along Mad River in east Dayton. Presently office quarters were acquired there, and in February, 1919, the offices were brought over alongside the factory and the removal into the present Delco-Light factory was complete. Today Delco-Light products are turned out in a large, well-appointed factory, the largest farm electric plant factory in the world. The buildings cover several city blocks, 13 acres of ground, in fact, and afford a million feet of floor space.



Home of Delco-Light, Dayton, Ohio, U. S. A.

In the beginning the company was incorporated as The Domestic Engineering Company and it operated under this title until January 1, 1920. On this date it became one of the units of the General Motors Corporation and was re-incorporated under the title Delco-Light Company.

We spoke of Delco-Light as having become a household word. "Household" was used advisedly. Unquestionably there is no piece of farm home equipment that takes quite so strong a hold on the affections of the entire family as does Delco-Light.

This is natural, for, once Delco-Light is really put to work on the farm, its influence is manifested in some helpful fashion during practically all the family's waking hours. There is the cheerful electric light, at the turn of a switch, in early morning, evening, or for midnight emergency. There is electric power to take the place of turning cranks on all household machinery and to revolutionize life for the farm family. Running water—all the appointments of the modern home anywhere: no wonder thousands write, as they do, that they would give up the automobile before they would Delco-Light—that they wouldn't part with it for twice its cost—or that Delco-Light represents the best investment they have ever made. Many Delco-Light users are able to substantiate their claims as to its investment features, with figures showing saving of labor and of time that mount up into hundreds of dollars in a year's time.

A prophet, it was said long ago, is without honor in his own country. But that isn't true of Delco-Light. It is a matter of considerable gratification to the makers that on the farms of Montgomery County, Ohio, where Dayton and the Delco-Light factory are located, there are more Delco-Light plants in operation than in any other single county or similar area in the world. No other encomium is needed.

THE CUTTER ELECTRICAL & MFG. CO.

PIONEER MAKERS OF THE SWITCH AND CIRCUIT BREAKER

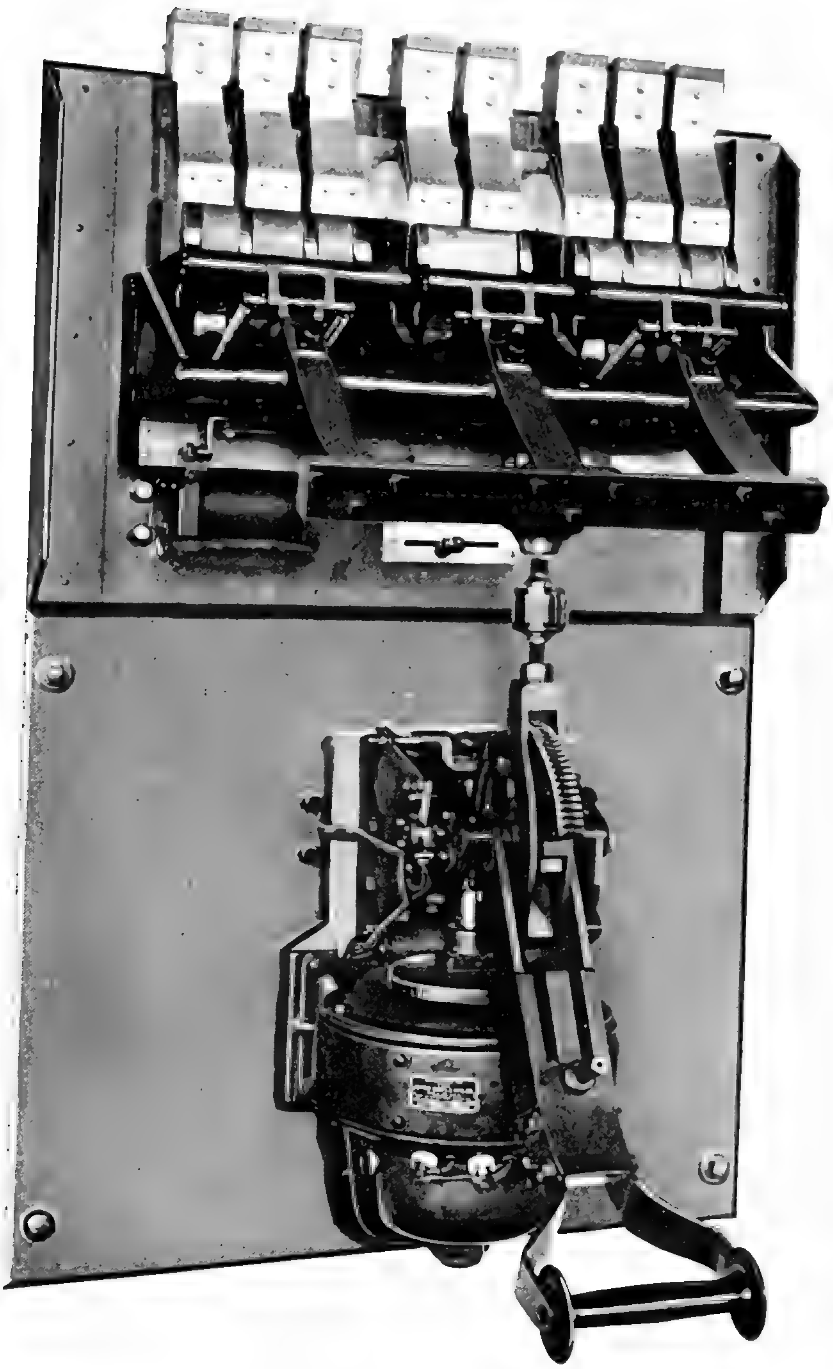
The Cutter Company, to use its briefer and more popular title, is one of the oldest electrical manufacturing companies in the country. The business was established by Henry B. Cutter, in Philadelphia, in 1888, and incorporated as a Pennsylvania corporation in 1890. A pioneer organization in the field of manufacturing electrical devices, it passed through the usual business vicissitudes, finally emerging from its difficulties and taking its place as one of the most respected manufacturing concerns in the country.

Its first contribution to the electrical art was a "push button" switch—a switch designed to be inserted *in,* not *on,* a wall. How the Cutter Flush Switch revolutionized the art of wiring houses, hotels and office buildings, is now a matter of history. The controlling patents having long since expired, the manufacture of flush switches is now open practically to all comers, but the part played by the Cutter Company in the design and manufacture of so important a device as a push button switch should not be forgotten in a work in which "The Story of Electricity" is told.

Emerson, one of our great American essayists, had hardly finished writing his famous sentence, "Of what value is the electric spark? It is the toy of the laboratory," when the greatest engineering minds of the world rose up to prove him wrong. In the lifetime of many not yet old men, we have seen the "electric spark" revolutionize literally, everything. We have seen the electrical industry grow from the least important to the most important industry in the whole world, because whatever electricity may be, and the experts are not yet entirely agreed, it is something upon which today all other industries are dependent. Think for a moment! Can you imagine where any of our most important industries would be without electricity? No need to confine our thought to those which are electrical, *per se,* like the telegraph, the telephone, or the trolley. Think of transportation in its widest sense, think of the manufacture of almost anything, think of the life itself in our great cities and on our farms; and then think of what life was before the blessing of electricity had permeated every nook and corner of the civilized world.

It is no reflection upon the pioneers in the electrical art to say that the devices first manufactured were crude and insufficient compared with those of today. "Good enough and safe enough for today, but not good enough and safe enough for tomorrow." might have been the slogan nailed to the top mast of every ship plying the unchartered electrical sea. From the very first there was an insistent demand for better, and better and more reliable electrical apparatus of every kind; and in so far as this demand could be met by the Cutter Company's organization, it fell upon sympathetic ears. This led to the production of an automatic electric circuit breaker, or cut-out as it was then called; and with the development of this device the Cutter Company has long been identified. The circuit breaker standard adopted by it has everywhere been accepted, and has become the standard of the world. What the B. & S. gauge and the Sellers thread are in their respective arts, the Cutter Company's standard is in the line with which it is identified.

For upwards of a quarter of a century the I-T-E circuit breaker, as the Cutter Company's device came to be called, has



Typical Cutter I-T-E Circuit Breaker

been used whenever strength, reliability and accuracy is of prime importance. At first, the chief function of the I-T-E circuit breaker was the protection of electrical circuits from the disastrous effects of overloads and short circuits. It was, in brief, designed for the service which had up to that time been afforded by a fuse, but with the growth of the electrical art, other and less obvious forms of circuit breakers were called for, and to these calls instant reply was made by the Cutter Company, which adopted for its slogan the well-known phrase: "The circuit breaker art of the world is what we have made it."

A. EDWARD NEWTON
President

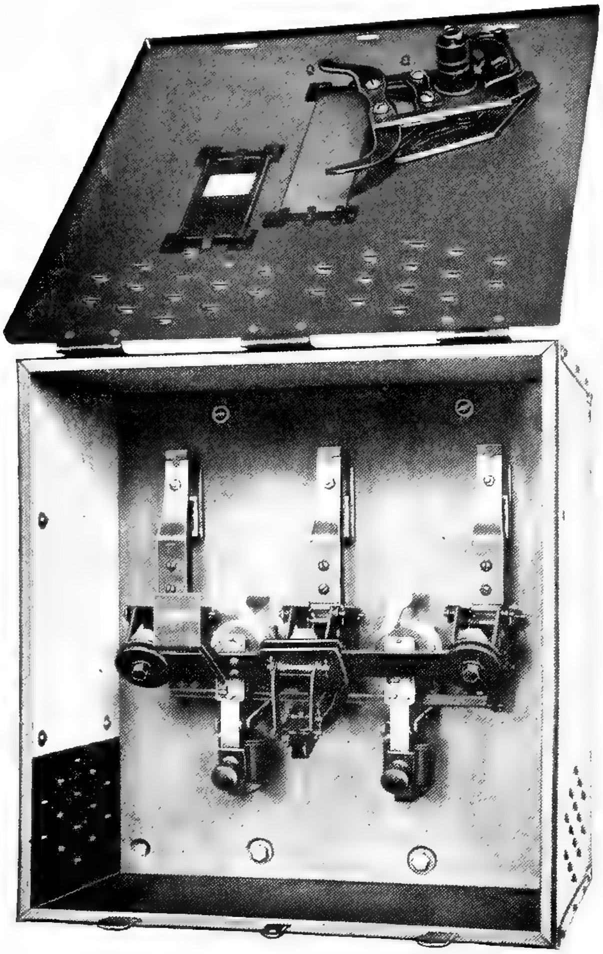
It would be quite impossible within the limits of such a publication as this to indicate in even more than the most cursory manner the range of the Cutter Company's work: briefly, it may be said that circuit breakers, protecting generators and motors and motor-driven machinery from the disastrous effects of overloads and short circuits are most common. In addition, special features such as "No Voltage," "Shunt Trip," and "Time Limit" are frequently supplied, and these again are differentiated into single, double, triple, or quadruple pole. Nor should the important question of voltage on which the different types may be used, be overlooked.

As yet nothing has been said in regard to the capacity, in amperes, of such devices as serve to interrupt in a fraction of a second overloads or short circuits of tremendous proportions. When an overload comes upon a circuit breaker, he would indeed be a wise man who would venture to predict its value or its limit. It might well be worth a hundred times the normal limit of the machine. Whatever it is, it must be taken care of, and that duty done the circuit breaker must be immediately ready again to respond to any demand which may be made upon it. It will be seen, therefore, that a circuit breaker must be so carefully designed and built of such material as to enable it to withstand the enormous mechanical strain to which it is subjected. Normally a circuit breaker is called upon to do little or nothing, but any instant it may be called upon to open under almost unimaginably severe conditions.

When A. Edward Newton became the financial manager of the Cutter Company in 1895, he staked all the money he had and some he did not have on the merit and success of the "I-T-E" Circuit Breaker, of whose value and relations to the art of electrical generation and supply, a brief consideration has been given above. As treasurer of the company, he managed to pay off a series of notes and by slow, sure degrees he established the financial credit of the enterprise which he has since carried to such marked commercial and engineering success. At that time he was only 32 years of age, with some experience in the electrical field, although his tastes and talents are recognized and appreciated elsewhere. It must, however, be taken as a certain measure of versatility that Mr. Newton besides being president of the Cutter Electric and Manufacturing Company, is treasurer of the Walker Electric Company, well-known as electrical engineers and contractors; and is also prominent in the affairs of the Windsor Chocolate Company and in the management of the famous Fleischmann's Vienna Bakery.

While Mr. Newton is not among those whose avocations become their chief business in life, it is at least "greatly to his credit," that he is one of the best known of American collectors of first editions of rare books, especially those of the Eighteenth Century, out of which has

grown his authorship of some of the most popular current books in the realm of bibliography and some of the most charming contributions to periodical literature through the pages more particularly of the *Atlantic Monthly*. This close association with letters is expressed in his



The I-T-E Circuit Breaker in the Steel Box
For the protection of polyphase motors and circuits.
Assures protection for equipment and safety for user

club membership—the Arts and the Philobiblion of Philadelphia, and the Grolier of New York, just as his social outlook is seen in the Merion Cricket Club of Haverford, and his technical affiliation in the Engineers and the Railroad Clubs of New York.

In the trade literature of the Cutter Company, Mr. Newton has found an excellent opportunity to combine business and his remarkable gift for description in a unique manner. It will suffice to refer to such admirable technical expositions as the "Handbook of the I-T-E Circuit Breakers" and the "Typical I-T-E Circuit Breaker Installations" as within this category; but the manual on "Protection" is not only a treatise on the control of electrical energy but a delightful epitome of business philosophy. One brief chapter follows:

"Mark Twain says: 'There are no "tolerable" eggs.' It's the same with circuit breakers—you can't tell how good they are till they're opened. Some circuit breakers open up 'rotten'; you will do well to avoid that kind.

"We have endeavored to tell in a plain, unvarnished way the life-story of a piece of scientific apparatus. We have told this story first one way then another; we have told it as George Ade might have told it were he in our business. We have told it with one eye on the face of the customer, trying to see whether we were boring him; and we have told it with the idea that this little book might perchance fall into the hands of a consulting engineer who wanted a plain statement of facts 'with naught set down in malice'; with but one thing in mind: to tell the exact truth, nothing more nor less.

"We know that our apparatus is the best of its class on the market; we know that our success is due not alone to our own efforts, although we have worked as hard as we know how to work, but to the fact that we have had these many years the cordial support of the consulting engineer. We have at all times endeavored to meet his wishes, and we believe that the esteem in which our apparatus is universally held is due in no small measure to the originality and ability of the engineer who tells us what he wants, why he wants it,—and who leaves the rest to us. We are not so bound down with our standards as to be either unable or unwilling to give him what he requires. We believe that it is the function of the consulting engineer to select what is best for the use of his client rather than what is easiest for the manufacturer to supply . . .

"Who is the best judge of what is required, the man who has made a careful

study of the conditions, or the salesman who, to sell a set standard piece of apparatus because more money can be made that way with less trouble? In the short run, money can be made by forcing the customer to buy what he does not want;

but we are not interested in the short run. Our business has come to stay, and we to stay with it.

"The requirements of the customer in no small measure determine our standards. The engineer who has followed the circuit breaker art knows this—knows that we have created what is best in circuit breakers; knows that we create standards and drop them the instant they can be improved upon. Progress is our policy. We can build anything in the circuit breaker line and build it right. Conditions of service largely determine our methods. When the best results can be secured by the use of a toggle, we use the toggle; when the best results can be secured by the use of a cam, we use the cam; when a coil to a pole is desirable, we use a coil to a pole; when one coil or two poles is sufficient, we employ that method. Some of our circuit breakers have latches, some have not.

"Some of our apparatus is operated manually, some by means of magnets, some by motors, by water or by compressed air. It's all one to us. Our idea is to adopt the best and simplest method to the work in hand; to build the circuit breaker in the right way; to put the right circuit breaker in the right place.

"This being our policy maintained through many years, we believe justifies us in asking the consulting engineer when drawing specifications, always to specify I-T-E Circuit Breakers. If he does we guarantee satisfaction alike to him and to his client."

This is making trade terms into literature, and clothing a commonplace circuit breaker in the atmosphere of an heroic best seller.

The Cutter Company is one of the old and familiar names in the electrical field. It bids fair to add increased prestige as the years pass on.

CIRCUIT
ITE
TRADE MARK
BREAKERS

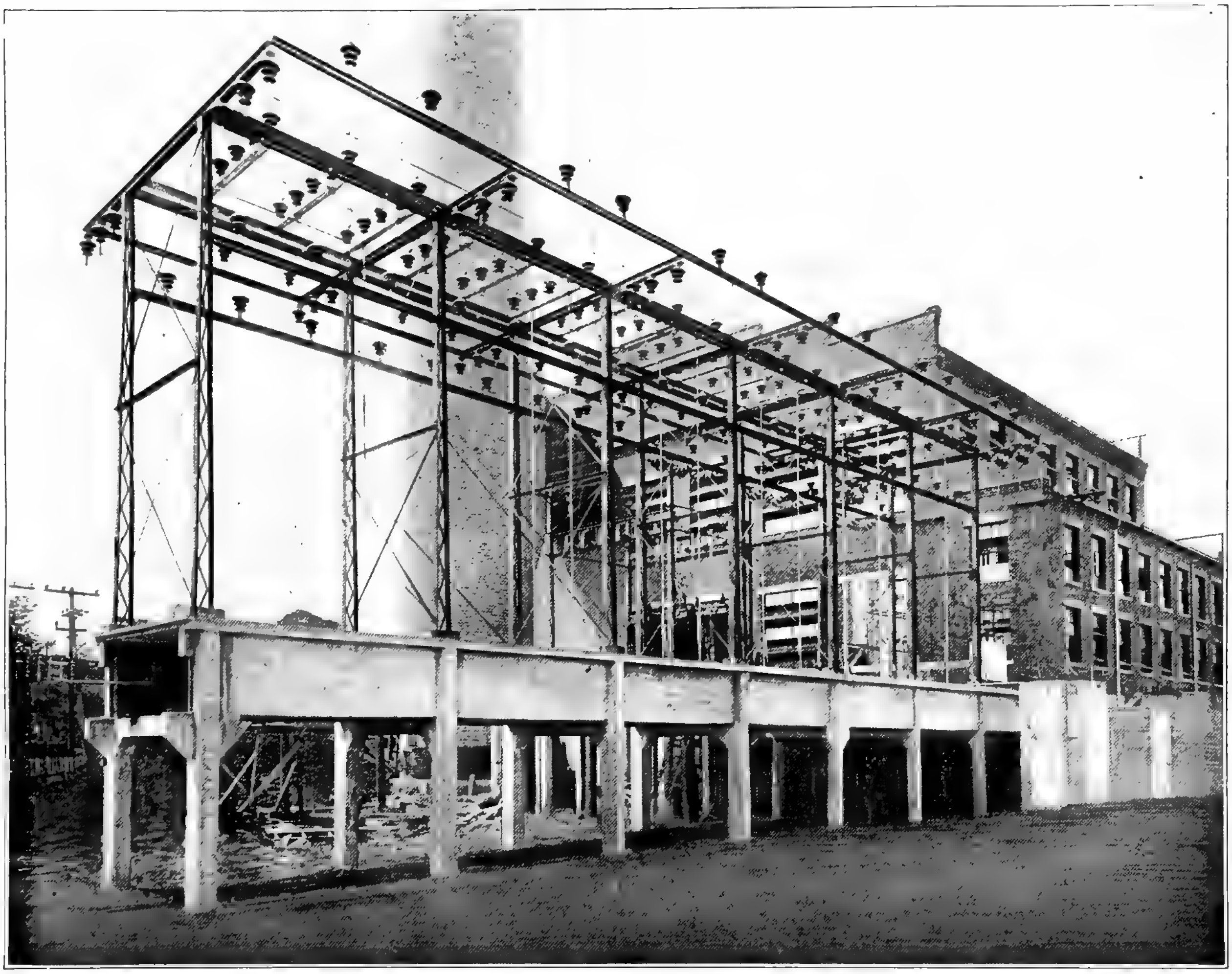
DELTA STAR ELECTRIC COMPANY

In an able paper read not long ago before the United States Chamber of Commerce, dealing with the "arrested development" of public utilities, it was remarked:—"Not merely in the cities but on the farms more progress must be made. There are 6,500,000 families living on farms in this country. The lives of 2,000,000 of these families have been made less burdensome by the introduction of electricity, but the conveniences must still be extended to the vast majority which still remains unserved." A chapter in the present volume of "The Story of Electricity" deals in a general way with some of the many problems and developments thus summed up; and it has there been indicated that progress is being made, even if still somewhat slowly, in supplying electric light and power to the 4,500,000 American farms not yet equipped with these agencies of modern civilization. That way, indeed, lies the promise and possibility of the new rural prosperity. As has been said by the *Electrical Review* in editorial discussion of farm life: "The electrical industry has the one most powerful agency for keeping the sons of successful farmers at home where they may prosper and continue to feed the nation. 'Electricity on the farm' will keep the boys at home and at

Delta-Star High Tension 13200-110-Volt Switching and Protective Equipment for Tapping High Tension Transmission Lines and Supplying Central Station Service to Farmers

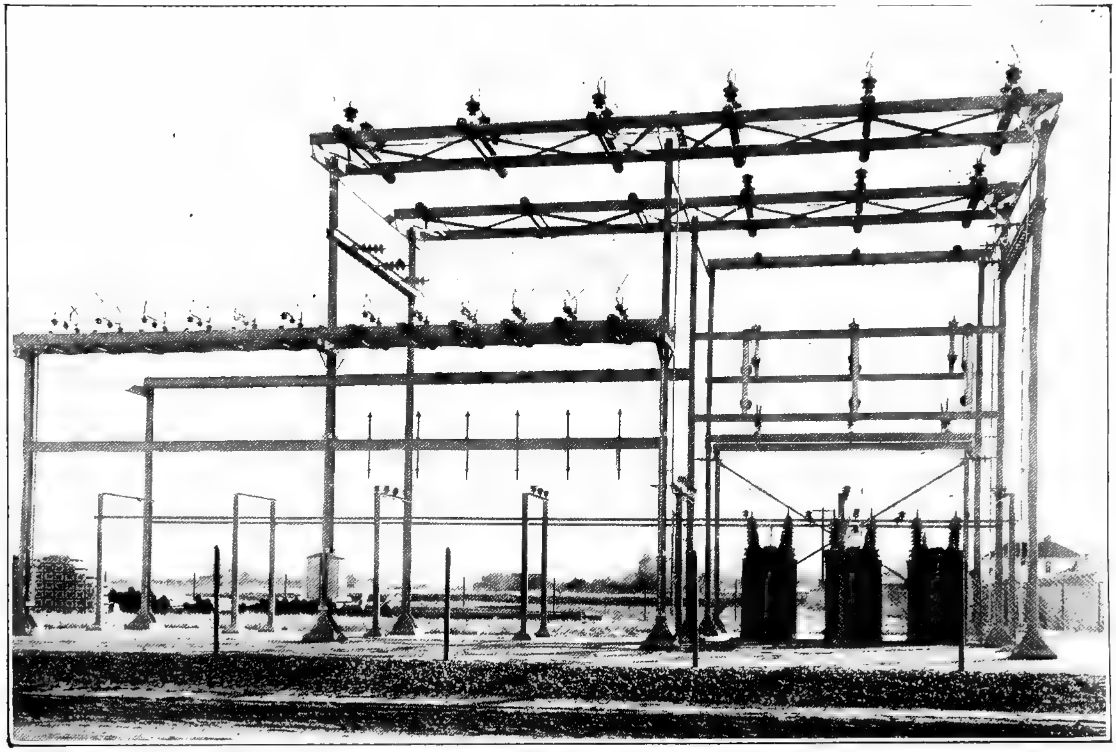
the same time help 'father' increase his earning power. In addition electricity can lift a great load from the shoulders of the farmer's wife. This probably is one of the most important elements in the entire proposition." While the automobile may be said to have made complete conquest of the rural field already, electricity, an even more pervasive medium of comfort and convenience, is a long way yet from coming into its own. The fact remains, for example, that in 81 per cent of the farm homes, water is still carried into the kitchen by hand. No bathtubs exist in 94 per cent of the houses, and worst of all, electric lights are wanting in 97 per cent of the houses, almost the direct opposite of the astounding proposition—apparently true—that 96 per cent of the farmers have a car even if it be only a "flivver."

Pioneer among the concerns that have boldly endeavored to deal with a situation of both discouragement and hope has been the Delta Star Electric Company of Chicago, of which Mr. H. W. Young is president, and Mr. A. S. Pearl is secretary. With a capital of $150,000, this progressive organization has already built up a business of $1,000,000 annual gross increasing at an average rate of 20 per cent, and broadly based upon conditions that will fructify with the return of prosperity to American agricultural regions. The



Delta-Star High Tension 33,000-Volt Unit Type Switching and Outdoor Sub-Station Supplying Light and Power to 8 Towns and 21 Coal Mines

work to which the company has applied itself with special success is that of "hooking up" the farmer with the nearest source of central station supply, as distinguished from isolated plant service. Great as may be the advantages of the isolated plant, as compared with oil lamps, small engines for power, etc., it cannot compare for one moment in economy and efficiency with central station supply; and this field has been opened up very largely by Mr. Young and his associates, with immense benefit alike to the farmer and the local central station or power transmission company.

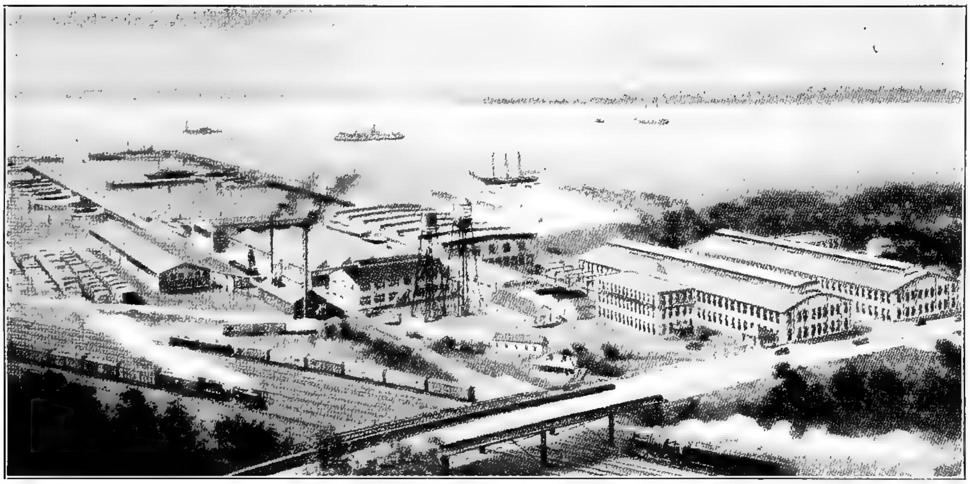


Delta-Star High Tension Unit Type 66,000-2300-Volt Outdoor Switching and Sub-Station Controlling Transmission Line and Supplying Power to a Community

It is very often found that one advance in invention and engineering carries with it many allied or correlated improvements little suspected at first. It will be remembered that Saul went hunting for strayed asses and secured a kingdom instead. The Delta Star Company in developing their standard units for farm service equipment have, at first unintentionally and unconsciously, become pioneers in the modern movement which is represented in the outdoor substation, an advance paralleled only by the invention of the transformer itself in the "farflung" distribution over large areas, at small cost, of electrical energy supply. While Europe is only now beginning to take up the idea, America is fully committed to it, and in the Delta Star "Unit" type of apparatus for the outdoor substation, dispensing with all buildings, is seen the realization of the economical demand of the hour for a saving in plant investment and the means of reaching at low cost not only the lonely farm but large factories or even whole communities, which hitherto had to deal with a seriously burdensome expense to secure electricity for light and power, or go without. The illustrations that accompany the present brief sketch show what Mr. Young has done since some years ago he began experimentation in the now splendidly developed field of outdoor high-tension substation distribution.

ELECTRO DYNAMIC COMPANY

The Electro-Dynamic Company commenced manufacturing motors and generators in 1880, in Philadelphia, Pa., and in 1904 moved to its present location at Bayonne, N. J., on Newark Bay, securing the favorable rail and water facilities of the New York metropolitan district. The company's line of manufacture at present comprises motors and generators ranging from one-half to one thousand horsepower in size for both alternating current and direct current.



Plant of the Electro-Dynamic Company, Bayonne, N. J.

In 1882 the American Institute of New York awarded "The Medal of Excellence for an Electric Motor" to Electro-Dynamic Company and in 1883 the Southern Exposition, Louisville, Ky., awarded to Electro-Dynamic Company a medal for "The Best Electric Motor for Domestic Use." Later this company acquired considerable prominence as owners of a patent on interpole direct current motors for securing variable speed which up to the time of the introduction of the interpole, had been considered outside the realm of possibilities for direct current electrical machinery. This patent was taken out by Mathias Pfatischer, who for many years was the company's consulting engineer and in 1908 on the recommendation of the Franklin Institute, the City of Philadelphia awarded to him "The John Scott Medal to the Most Deserving for his Variable Speed Motors."

Not only was the interpole feature patented and developed by the Electro-Dynamic Company, but the word "interpole" itself was coined at the Bayonne plant and motors known as "interpole motors" have been widely distributed in interstate commerce by this company for many years.

This company was also the first to apply ball bearings to electric motors; which feature has also been widely copied by other manufacturers during the past two decades. These two progressive engineer-

ing developments feature the company's distinction as pioneers and pathfinders in the present perfection of the art of electro dynamics. The one improvement eliminated the destructive effect of sparking at the brushes and commutators of direct current machinery, due to armature reaction; and the other largely eliminates the breakdowns of both alternating and direct current motors due to bearing failures and the consequential troubles brought about in rotating electrical machinery due to wear of bearings and the carbonization of the insulation of electrical windings and commutators due to the secondary cause of lubricating oil being carried from sleeve type bearings on to the electrically conductive parts of the machinery. In addition to this, the reduction of friction losses by the use of ball bearings results in a considerable operating economy over a period of years.

During the World War, Electro-Dynamic Company coöperated 100% with the Government; one of its chief contributions being the furnishing of the preponderant part of the main motor drives as well as auxiliaries for the Government submarine boats, in addition to furnishing a considerable volume of such equipment for our Allies. Nothing can discount that vital service to the country.

The company is intimately associated with the development of electric motors for marine work, in addition to the business of equipping submarines, although the greater bulk of its business today is the furnishing of the highest possible quality of motors for use in the steel industry, textile mills, machine shops, foundries, stone, clay and glass industry, paper, food, chemical, lumber and leather industries, etc. For the purpose of rendering the necessary sales and engineering service, sales offices are maintained in many of the principal cities of the country.

COOK ELECTRIC COMPANY

This corporation was formed in January, 1914, to take over and operate the business of Frank B. Cook, and until October, 1918, it was known as the Frank B. Cook Company.

Mr. Cook is one of the pioneers in the telephone field, being employed at an early date by the Bell Telephone interests at Toledo, Ohio. He later became chief engineer of the Central Union Telephone Company, which position he relinquished in 1897.

Soon after this, Mr. Cook organized the Sterling Electric Company of Illinois, which undertook to develop and manufacture a line of telephone protective and distributive apparatus. A year later the business was transferred to the Sterling Electric Company of Indiana with factory and offices at La Fayette, Indiana. Mr. Cook remained president of this company till October, 1902, when he resigned, went to Chicago and undertook to manufacture telephone protective and distributive apparatus and market it under his own name.

The company manufactures central office terminal and distributing racks, heat coil and fuse protectors, several types of pole cable terminal devices, lightning arresters, and other apparatus used in the construction and maintenance of telephone and telegraph and signal line. Among the many valuable patents held by the company is one covering a self-soldering circuit breaker protecting device. The company has built up its business largely with the independent telephone interests in the United States and in foreign countries.

In 1915, George R. Folds became an official of the company and Mr. Cook withdrew from active management of the affairs. Mr. Folds later became president and continues in that office. The Cook Electric Company has its principal manufacturing plant located at Zion City, Illinois, and its principal office and an auxiliary factory at 900 West Van Buren Street, Chicago, Illinois.

NATIONAL METAL MOLDING COMPANY

One of the most interesting fields of electrical development with whose history the general public, or even the electrical public, has little or no familiarity, is that which embraces the art of interior wiring. Even this art subdivides into two very distinct departments, viz., the wire itself and the method of its introduction. When the electric light was introduced, it was quite the common practice to carry the wires on porcelain knobs, hold them down to the woodwork of a room by cleats, imbed them directly in the plaster, or slip them into the grooves of crude molding, of which the carpenters and cabinet makers turned out a great variety. Lamp cords found great popularity; and at first the combination fixture for both gas and electricity enjoyed considerable vogue. People were not sure that the electric light might continue to burn, and they clung to the old love before they took on exclusively with the new.

Then by irresistible process of evolution and improvement came the resort to "interior conduits," or pipeways through which the conductors could be installed all the way from the entrance to the building to the remotest lamp or other appliance utilizing the current; and here again came the opportunity to exert a lot of ingenuity and invention. Beginning with mere paper tubing the interior conduit art, over a long term of years worked out many problems in the effort to meet all the exacting protective requirements of insurance companies and safety inspectors, while avoiding the infliction of heavy cost on the means of distribution. It is to the perfection of such wiring methods no less than to the development of improved devices for consumption that is due the enormous domestic and industrial success of electric light, heat and power.

Along the lines thus briefly indicated, the National Metal Molding Company has been for many years in active pioneer leadership in the vast field of interior wiring, for which it has furnished a wide range of materials and appliances, due not only to expert technical skill and engineering but based on knowledge of the requirements of a very exact branch of electrical service. A great deal had to be learned and forgotten in carrying the art forward through a period of rapid advance and intense competition, of which the company is a signally prosperous survivor.

A department of the work with which the National Metal Molding Company has been specially identified with large significance even outside its own product is the development and application of the Sherardizing process to rigid conduit, metal molding and various types of fittings. There is also its Economy black enameled conduit; while at the other extreme, in perfected form but harking back to the earliest days of the industry for their fundamental idea, are such ingenious and useful specialties as the "flextube," non-metallic, flexible conduit, and the auto-flextube, a non-metallic automobile conduit. Intermediate to these are the admirable spiralized metal specialties, the "flexsteel conduit" for general work, and the "auto-steel-flex," an automobile conduit, notable for carburetor and exhaust tubing. Indeed, it might be said of the latter that they have been of enormous value in hastening the "horseless age" of highway transportation.

There are a number of other "N.M.M." products of deserved reputation, but of which only passing mention can be made here, such as the "National Metal Molding" the standard for surface wiring; the flex-steel armored conductors, National metal brackets, Liberty rubber-covered wires and cables, outlet boxes and covers, fixture studs, locknuts, bushings, etc.

The company attributes its success to "continuous maintenance of stable selling policies, distribution of material through authorized electrical jobbers; strong advertising of merit; and the underlying superior qualities of the goods themselves," now known so widely throughout all the world. The company, which was first established in 1906, has a capital of $1,000,000 and a surplus of $3,200,000. Its headquarters are in the Fulton Building, Pittsburgh.

CHAPTER XIX

CANADA AND ITS ELECTRICAL STORY

NO other modern national development rivals that of the Dominion of Canada, the great leader amongst the commonwealths that have grown up under the flag of the British Empire. The period that has witnessed such marvelous growth and advance dates only from the birth of the Confederation in 1867. Europe has recently seen the birth of some new "nations" and the restoration of some ancient peoples to nationhood and the exercise of free government; but they emerge from the pall of devastating war and hideous destruction, and it will be long before they can even make a fair start in the enjoyment of prosperity and its attendant civilisation. Let it not be supposed that the creation of the Canada of today was without tremendous difficulties and serious obstacles, with evil legacies and burdens from the dynastic rivalries of Europe that had been fought to a finish on Canadian soil. As has been well said: "The conflict for the New World was but the continuation of an age-long antagonism in the Old, intensified now by the savagery of the wilderness and by new dreams of empire." Canada, as it reviews its own happy experiences of the last fifty years, can but wish the newer European nationalities, last born in the blood-stained areas across the Atlantic, peace and prosperity equal to its own. It dedicated its sons and treasure to help set them free, and clear the path of liberty for them.

This is not the place to dwell upon the story of the New France, the romances of early Canadian settlement, the hewing out of vast new Provinces, the conquest of new grain fields, the expansion to the Pacific Ocean, all of which is so fascinating that one would prefer to linger over it. The object is rather to note briefly the general conditions of Canadian growth commercially and industrially as related to the advance of the Dominion in the arts and applications of electricity.

Agriculture is, of course, a prime industry in Canada. In 1920, the value of its field crops, reached the enormous sum of nearly $1,500,000,000. As far back as 1915, she produced wheat to the quantity of nearly 400,000,000 bushels; and it is notable that there is not any evidence of a depleted soil but that on the contrary, a steady increase in the grain per acre is observed generally. Moreover in 1921, Canada sowed 18,737,000 acres to wheat, or 500,000 acres more than in 1920. One remarkable thing is to find tobacco growing as far north as Ontario, which is only in keeping with the pushing of the wheat fields up into the regions of the Arctic. Forestry in Canada is another great industry; and whereas thirty years ago she exported $120 worth of wood pulp, in 1919-20 her sales of pulp wood, pulp and

paper reached the sum of $120,000,000. American newspapers would virtually be put out of business but for their supplies from over the border. Nor is Canada nearing the exhaustion of her lumber supplies, like the United States. The total stand of commercial timber in the Dominion is well over 500,000,000,000 feet, and it is estimated that under existing conditions the raw timber supply is good for another 200 years; while reforestation is becoming a national issue.

Turning to mines, it is remarkable that only 35 years ago was the search for them begun in earnest. Now they produce a revenue of over $200,000,000, or $25 per capita for a population of 8,000,000. Already, in the production of nickel, cobalt and asbestos, Canada is far in the lead of any other country. And now, even at this writing, the world is startled with the story of the discovery of vast new rich oil fields in the Far Northwest, whose prompt exploitation may well mark the beginning of Canada's new and unexampled era of prosperity. It must not be overlooked that Canada is already known to be in possession of over 16 per cent of the world's coal deposits,—or half of those of the whole British Empire; and that, with reference to questions of heat, asbestos from Canadian mines meets 88 per cent of the requirements of the world.

The railroads of Canada are one of the great features of her national development, and at least two of them enjoy the widest international reputation—the old Grand Trunk and the Canadian Pacific, the former completed in the early fifties, the latter dating from 1886. A new period might be said to have begun in 1916, when the first steps were taken by the Government toward acquiring the Canadian Northern; but the results of such a policy of Nationalisation have already proved so disastrous, it seems likely that as in the United States and as in so many other countries where the plan has been tried out, the Dominion may recognise the fact that the railroads are best out of politics and under vigorous but regulated private management. At the moment, the Government owns or controls 20,224 miles out of a total mileage of 51,338. On the basis of 1918, there was already a deficit of nearly $50,000,000 for 1920, with a serious tendency to growth of debt and a large demand for further investment of public moneys.

Be that as it may, the fact deserves mention that as has been said elsewhere: "After a few years of comparative struggling the Canadian Pacific Railway rose steadily to be the strongest and most prosperous railway in the world"; while the modern industrial and agrarian prosperity of the country dates in large measure from the day when the splendid span of steel rails was finished that gave the Dominion its first transcontinental railway. The gross earnings of all the Canadian lines had reached over $492,000,000 by 1920, but the ratio of operating expenses to gross earnings had risen to 97.2 per cent; although this was offset by an increase of trainload to 457 tons and of carload to 23.05 tons. All of this great system of transportation is supplemented by a really magnificent network of inland waterways, the largest in the world; and on her canals Canada had spent by 1920 no less than $178,427,000, with a result that of wheat alone the enormous quantity of 142,000,000 tons has been moved eastward in a single season; while the total traffic of all the canals has reached 52,000,000 tons as a maximum; with the significant condition that 80 per cent of the business is American in origin and destination.

A few other vital data may be given before passing on to the specific consideration of the electrical conditions. For instance, the fisheries of Canada are of unparalleled magnitude, the seventh heaven of the deep water fisherman and the "Paradise of the angler." It is stated that the commercial fishing of the Dominion now yields an income of over $50,000,000 with unlimited opportunity for expansion, although 100,000 tons of cod, 100,000 tons of herring, and 62,000 tons of salmon were captured, while even oysters weighed 3000 tons, and of the lobster, now so scarce in the gilded restaurants of the Great White Way, no less than 20,000 tons.

Turning to the industrial development

of Canada we find that in 1918 the value of the products of Canadian factories had risen to the impressive total of $3,458,-000,000 the leading items being: Log products, 146 millions; steel furnaces and rolling mills, 209; pulp and paper, 119; foundry and machine shops, 82; flour and grist mills, 262; cars and car works, 106; slaughtering and meat packing, 185; bread and confectionery, 85; smelting, 62; building and contracting, 60; iron and steel goods, 20; boots and shoes, 46; sugar, 59, and electrical apparatus, 30—of which more anon. With regard to finance, it may be mentioned that in 1920 the chartered banks of Canada had a paid up capital of $128,066,769 and total assets of $3,056,979,489; reserve of undivided profits, $133,048,505; and in view of a population of 8,600,000 it fairly may be asserted that no country is more adequately provided with sound banking facilities represented by 18 great banks with nearly 5000 branches. During the great war, Canada raised for internal loans in excess of $2,000,000,000 and her total war expenditure was $1,640,000,000; so that her total national debt is now about $2,082,000,000. The credit of the country was never better than today whether in Europe or in the United States, which has recently manifested such a strong liking for Canadian bonds as evidenced by the fact that in 1919 not less than 22.54 per cent of the issues was taken up eagerly south of the St. Lawrence. It is estimated that in 1920, the total value of the agricultural wealth of the Dominion was not less than $7,612,000,000 but that was only half of her total wealth. Her capital employed in industry was $3,034,-000,000 in 1918, with a value of output per employee of $5,097. A further striking evidence of the appreciation of Canada as a market is the fact that in 1920 it was estimated that there were some 500 branch firms of United States concerns operating in the Dominion, with an average capital of $300,000 or a total of $150,000,000. Finally, in 1921, the total foreign trade amounted to $2,450,587,-001—57.09 per cent being done with the United States or over twice as much as with Great Britain, which was 21.5 per cent of total exports, or more than with all the other countries combined. As to this foreign trade, the following recent statistics will suffice: "In the year ending with September, 1921, Canada exported goods in the following values: Wheat, $293,379,-000; paper, $82,457,000; iron and steel, $35,392,000; flour, $67,953,000; lumber, etc, $86,257,000; pulp, $43,038,000; animals, living, $21,344,000; fish, $31,-954,000; bacon and ham, $27,681,000; butter, $4,075,000; cheese, $29,295,000; coal, $15,017,000; furs, $12,815,000; textiles, $7,630,000; vegetables, $3,843,000, and automobiles, $7,298,000. That is an extremely creditable showing for a comparatively sparsely settled country covering half a continent and with a population of only 8,600,000 scattered over its 3,-730,000 square miles.

"Geographical and climatic conditions will always make Canada an active market for many products which the country itself cannot produce, or cannot produce in sufficient quantities to meet the requirements of the home market. The following summary of the principal imports into Canada for the same period as the exports named above shows that the following purchases were made by Canadians from abroad: Iron and steel, $138,631,000; cotton, $51,721,000; sugar and molasses, $59,-080,000; wool, $35,917,000; anthracite coal, $41,537,000; bituminous coal, $63,-710,000; silk, $20,457,000; vehicles, $20,970,000; breadstuffs, $14,918,000; chemicals, $16,962,000; hides and skins, $5,106,000; rubber, $9,351,000; flax, hemp and jute, $8,059,000; tobacco, $11,623,000; leather, $6,597,000, and tea, $7,744,000."

CANADA'S WATER POWER RESOURCES

In all this mass of statistics, which, it is hoped, have not proved at all wearisome, practically no reference has been made to Canada's stupendous source of energy and weath—her illimitable water powers, rivalling, if not exceeding in importance all her coal and oil and natural gas. This brief section dealing with the subject will serve as a connecting link, in

this chapter, between the more general data about the Dominion and that to follow relative specifically to its electrical industries. The Dominion Water Power Branch of the Department of the Interior and the Dominion Bureau of Statistics, Department of Trade and Commerce, published quite recently figures which are complete to Jaunary, 1920, on the developed water power of Canada, and furnishing a census of this grand source of power as a whole. It appears that the water power resources of the British Empire in the aggregate have been placed at from 50,000,000 to 70,000,000 horsepower. If the former figure is near the mark, Canada would appear to have nearly 50 per cent of the total, as her water powers are estimated at a minimum of 20,000,000 horsepower, based on sites already known about which fairly definite information can be had.

3,385,000 hp. Of the total power installed no less than 72.7 per cent is installed in central electric stations, whose energy is sold for lighting, mining, manufacturing general power purposes, and electro-chemical and electro-metallurgical work. The distribution of this power by location and uses is given in the accompanying table below:

As a supplement to these mass figures, note should be made of one or two of the leading hydro-electric developments in Canada, beginning of course with the incomparable Niagara Falls. With regard to the utilisation of the Canadian power frequent reference will be found to the subject in the biographical sketches of Vols. 1 and 2 of the "Story," such as those of E. D. Adams, the Schoellkopfs, Thomas Ahearn, P. G. Gossler, and others who have had a leading share in the great work.

DISTRIBUTION OF DEVELOPED WATER POWER IN CANADA

	Developed Water Power					
		Total Waterwheel and Turbine Horsepower Installed for Use in				
	Total Waterwheel and Turbine Horsepower Installed	Central Electric Stations	Pulp and Paper Industry	Other Manufacturing Industries	Total Horsepower Actually Employed	Ultimate Capacity, Horsepower
Yukon	13,199	10,000	....	....	11,349	13,199
British Columbia	308,167	211,043	46,962	46,094	276,795	350,832
Alberta	32,992	32,580	....	17	31,754	33,070
Saskatchewan	....	....	....	....	....	....
Manitoba	83,447	71,790	....	....	75,100	297,047
Ontario	1,015,726	794,621	158,095	99,230	934,015	1,460,920
Quebec	910,029	623,088	249,332	270,961	838,071	1,146,465
New Brunswick	18,080	9,378	2,693	6,009	16,657	29,115
Nova Scotia	34,323	4,064	16,183	12,276	29,359	52,202
Prince Edward Island	1,933	227	....	1,789	1,621	1,958
Totals	2,417,896	1,756,791	473,265	436,376	2,214,721	3,384,808

Ultimate designed capacity of plants now operating or under construction in hp.

It is found that of this available power, only 10 per cent is now developed, or in other words, there is now installed throughout the Dominion 2,418,000 hp. in turbines, of which 2,215,000 hp. is employed in actual work. The ultimate capacity of such plants and such new ones as are now under construction totals about

First seen by the white man when Father Hennepin visited them in 1678, it was but slowly that the idea developed of using the power of the Falls at Niagara; and even then the only attempts were simply tiny saw and grist mills. De Witt Clinton, father of the Erie Canal, noted in his journal in 1810 that the beautiful

Cataract was "the best place for hydraulic works in the world"; but this broad hint was without stimulus until 1842, when Augustus Porter invited attention to the matter, with the result that the Niagara Falls Hydraulic Company was formed in 1853, the year when work actually began on the canal, 35 feet wide, 8 feet deep, and 4,400 feet long—thus marking the modern era that sees the Falls as the greatest hydro-electric centre in the world and a source of energy for cities as far away as Toronto, Buffalo, Hamilton, Windsor, Sarnia, Rochester and Syracuse. To realize what is possible at Niagara, it should be remembered that it drains an area of 300,000 square miles, and releases the brimming flow of 90,000 square miles of reservoir area, with an overspill of about 275,000 cubic feet per second. The actual quantity of water passing has been estimated to reach as high as 100,000,000 tons an hour, with available latent energy of from 5,000,000 to 7,000,000 horsepower; while the total developable power of the basin is put at a possible 10,000,000 hp. of which at present 1,000,000 is being developed in the United States and 1,500,000 in Canada. Let us try to imagine the coming day when economising in the use of precious coal and oil in that area, all the ten million horsepower are employed by Canadians and their cousins of the United States! Subject to the condition embodied in the remark: "The destruction or serious defacement of Niagara Falls or any part of it, for power, development or commercialization of any kind, would be held almost universally to be intolerable vandalism." In the meantime, the process of utilization is slowly having its effect, without any diminution of the natural beauty, and in reality with considerable enhancement of scenic effects, while the development of power, strange as it may seem, has the effect of preserving the Falls, which under the crude, damaging assaults of water and weather have been tending in their travel westward, backward toward distant Tonawanda, to degenerate into a long low series of rapids, instead of the existing glorious plunge in mass through nearly 200 feet from Lake Erie to Lake Ontario below. What has been done in developing from 600,000 to 700,000 hp. at the Falls is shown in the table herewith:

WATER DIVERSION FROM NIAGARA RIVER AT NIAGARA FALLS

Side of River	Name of Company	Division Cu. Ft.	Totals per Second
United States	The Niagara Falls Power Co.:		
	Niagara Plant	8,600	
	Hydraulic Plant	10,900	
	Pettebone Cataract Paper Co.	270	19,770
Canada	Hydro-Electric Power Commission of		
	Ontario Power Co. plant	11,200	
	Toronto Power Company	12,400	
	Niagara Falls Power Co., Canadian Plant	9,600	
	International Railway Co.	125	33,325
Grand total			53,095

Elsewhere in this volume the story of Shawinigan is told separately, and other items bring to attention the fine development at Ottawa, but we could not omit some reference to the rather daring enterprise undertaken by the Hydro-Electric Power Commission of Ontario created in 1906, and which for some fifteen years has given a vivid illustration of the advantages and drawbacks of Government control and operation in regard to an engineering and commercial undertaking of the first magnitude. Under an agreement of 1907-8, with the Ontario Power Company, the Commission made a bold step, in agreeing to take 100,000 hp. for municipal use and retail distribution; and up to October, 1914, the Commission bought all of its energy from private producers in this way.

At that date, with the completion of its own plant at Wasdells Falls on the

Severn River, it became a generator of power on its own account; and thus entered upon the second definite period of development and administration. The Commission next acquired the entire property of the Ontario Power Company and its obligations, in 1917, including the Ontario Transmission Company and the Niagara, Lockport and Ontario Power Company. An almost necessary sequel to this was the taking over in September, 1921, of a large group of electric light and power interests in and around Toronto at a price of $32,734,000. Some of the properties included in the deal were the Toronto Power Company, the Toronto & Niagara Power Company, at Niagara Falls, the Electrical Development Company and the Toronto Electric Light Company. Beyond all this, the Ontario Hydro-Electric Commission has undertaken and has now well advanced toward completion a huge addition to the Ontario Power Company's plant, increasing the water diversion of that plant to about 13,300 feet between Chippewa above the Falls and Queenston below, and developing 300,000 hp. under a head averaging 305 feet. In view of all this activity in acquiring and developing electrical energy, it will now be understood why the Province of Ontario with 366 central stations, or 46 per cent of all in the Dominion, has 216 stations that have no generating plant of their own, of which 204 are municipally owned. The Commission sells to all such in bulk leaving the distribution of the elecrical energy as a matter of local municipal administration.

THE CENTRAL STATIONS OF CANADA

As will be observed, this brings us to a consideration of the central station industry in Canada as a whole, and the figures are briefly summarised as of 1918. The number of central electric stations reported for the Dominion in existence January 1, 1919, was 795, of which 515 generated their own power and 280 purchased energy from generating and distributing plants. Of the 795 plants, 418 were municipally owned, but the other statistics of investment and operation were by no means in the same ratio; and, as already noted, the Ontario Hydro-Electric Commission is to be credited with a large proportion of the local plants purchasing power in bulk. The capital invested was put at $401,942,402, of which 71.7 per cent was private, so that only 28.3 per cent was municipal. The total revenue derived from the sale of power was $53,549,133, of which $33,190,882 was private and $20,358,251 was municipal. Of this revenue, $16,952,512 came from lighting and $36,596,621 from all other uses. The total number of employees, including officials and wage earners was 9696, to whom was paid $10,354,252 per annum.

The primary generating installation of these central stations totalled 1,841,114 h. p., of which 1,434,196 h. p. was in commercial or private plants and 406,918 h. p. in municipal. Incidentally it may be noted that no precise data are at hand as to isolated plants in Canada, but it is believed that the proportion is much lower than in the United States as compared with public utility development. The classification of the primary power thus disclosed is as follows: Of the 1,841,114 h. p. installed, no less than 1,682,191, or 91.4 per cent, is derived from water, 145,637 h.p. from steam and 13,286 h.p. from gas and oil. The total k.v.a. electrical generator capacity was 1,433,722, of which 78.1 per cent was commercial and 21.9 per cent municipal. The total primary power installed in central electric stations throughout the Dominion averages 20.9 h.p. per 1000 of population and the k.v.a. dynamo capacity averages 162. Unfortunately data are not available as to the number and variety of electrical current consuming apparatus installed on the circuits of the various systems; the extent of street lighting, the number of meters or the number of customers. As will be noted, all the data given above are relative to 1918, when the total water power installed was stated to be 1,682,191 h.p.; but Mr. James White, of the Commission of Conservation, Ottawa, under date of August, 1920, stated that on January 1, 1920, the total water power installation in Canada

was 2,417,896 h.p.—which, if true, would mean a marvellous growth in barely two years, but it is supported by the detailed table which appears in this chapter. A fair inference would be, however, that a very large proportion of the difference between the two figures is accounted for in isolated hydraulic installations. If of the 735,705 h.p. difference shown, 250,000 h.p. is allowed for the central station increase, there would appear to be about 500,000 h.p. of isolated water power plant in the Dominion, or 25 per cent of the total.

It is not to be inferred that steam power is a negligible factor in electrical development in Canada as a whole. Mr. H. Wray Weller, C.E., a well-known authority on the subject, has been good enough to furnish some interesting data and details on this subject; and he remarks that in the Central or Prairie Provinces, industry in general has to depend to a large extent on steam. Even in the territory served by water power, it is found necessary to use steam as a reserve, especially in the East, where the intense cold of the Canadian winter causes interruption in the water supply, and creates difficulties due to "frazil" ice. From his own experience with the introduction of the Canadian Babcock-Wilcox boilers, Mr. Weller is able to furnish one or two interesting notes or sidelights. Thus in Toronto, in the heart of the water power region of Ontario, the Toronto Incandescent Electric Light Company, which started in 1889 with three 125 h.p. horizontal return tube boilers, has now 20,000 kw. of generators for light and power driven by 8200 h.p. of such water tube boilers; and there is 10,000 kw. of generators and 60,000 h.p. of boilers in service for trolley transportation. Thus, too, in Winnipeg, while there is 50,000 k.v.a. capacity in the city hydro-electric plant, at Point du Bois, and about 30,000 k.v.a. in the hydro plant of the Winnipeg Electric Railway, the steam standby stations in the famous city of the plains aggregate 13,500 k.v.a. generated by steam from Babcock & Wilcox boilers. In like manner, to-day in the city of Montreal, the various utility companies supply a total of approximately 170,000 k.v.a. generated by the various hydro-electric plants, notable among which is the great system at Shawinigan Falls, some 84 miles away. But this is supplemented by not less than about 50,000 k.v.a., the steam for which is furnished by an aggregation of 22,000 h.p. of Babcock & Wilcox boilers. And so one might go on, in regard to Ottawa, Hamilton, Calgary, Halifax, St. John, Moose Jaw, Saskatoon, Edmonton, Regina, Medicine Hat, Lethbridge, Weyburn, Prince Albert, Banff, Battleford, Kamloops, etc., where the modern electric plants have a kindred boiler equipment. It is interesting to note not only the increasing pressure, beginning with 100 pounds up to 200 and even 250 pounds in the latest installations, but the increase in the size of the unit. In the early days, as in the United States, 125 h.p. was about the usual limit, while to-day units of 1000 h.p. are to be found in various parts of the Dominion, equipped with the "last cry" of accessories in the form of steam superheaters, mechanical stokers and coal handling machinery. As Canadian manager for Babcock & Wilcox for the past 21 years, Mr. Weller has not only seen this great change, but it is largely due to his own engineering skill and efforts; so that he can point to over 500,000 h.p. installed in Canada. Paradoxical as it may sound, the statement might justly be made that the hydro-electric development of Canada has been largely aided by steam power, and the growth of each, as the figures show, has been extraordinarily interesting in recent years.

ELECTRICAL MANUFACTURING

In the earlier days of modern electrical development, Canada derived much of its material and supplies from the United States, and pretty nearly all the rest from England. The "parent companies" of the United States, in the electric light and trolley fields, found the land over the border very alluring, and they also received many invitations to come across; besides which the Canadian patent law required a certain amount of home manufacture. The "National policy" made itself felt very specially in the electrical arts, and the re-

sults were surprising. The Westinghouse system, for example, was early taken up by those splendid and typical Canadian pioneers, Ahearn & Soper, whose imprint has been deeply made also in other branches of public utility enterprises. The Edison lighting interests were soon taken up in the Dominion, and these were in due course acquired by the Canadian General Electric Company, under the vigorous leadership of the late Hon. Frederic Nicholls. The same company acquired also many of the early Thomson-Houston Canadian patents, as well as some of those of Prof. Elihu Thomson personally, of Mr. J. J. Wood, and of other leading American inventors and parent companies. In 1894, this corporation had a paid-up capital of $1,500,000, and a factory at Peterboro, Ont., which even in that year of universal depression, had nearly 500 names on its payroll, and was running when visited by the present writer, 24 hours a day. As was said at the time in *The Electrical Engineer:* "The Canadian General Electric Company is one of the largest engineering concerns in the British Colonies; it is undoubtedly far larger than any other electrical company in the colonies, and for variety of product probably has but one equal even in England itself." Even at that early day—nearly 30 years ago—Canadian electrical apparatus was well known and had been used in the Government power and lighting plant at the Sault Ste. Marie Canal; on the beautiful double-track electric trolley road around the Niagara Falls Gorge; in the electric coal mining at the famous Nanaimo beds of British Columbia; and generally in light and power enterprises from the Atlantic seaboard to Winnipeg and clear across the Continent to Victoria, Vancouver and New Westminster.*

Today the electrical manufacturing establishments in Canada are legion, with a supplementary legion of wholesale, distributing and supply houses, in regard to which reference may be made to any issue of the Canadian *Electrical News.* According to the general review of manufacturing in 1918, issued by the Dominion Bureau of Statistics in January, 1921, the electrical apparatus and supplies produced in 1918 in Canada were of a value of $30,045,399, made by factories with $43,285,405 capital, employing 8859 persons and paying wages to the amount of $8,449,841. There were other products not strictly of an electrical nature, but of practically electrical application exclusively; while the figures just given do not include any of those relating to the electro-metallurgical and electro-chemical processes now in extensive use in Canada.

* "The Development of Electrical Manufacturing in Canada," by T. C. Martin. The *Electrical Engineer,* New York, Sept. 19, 1894.

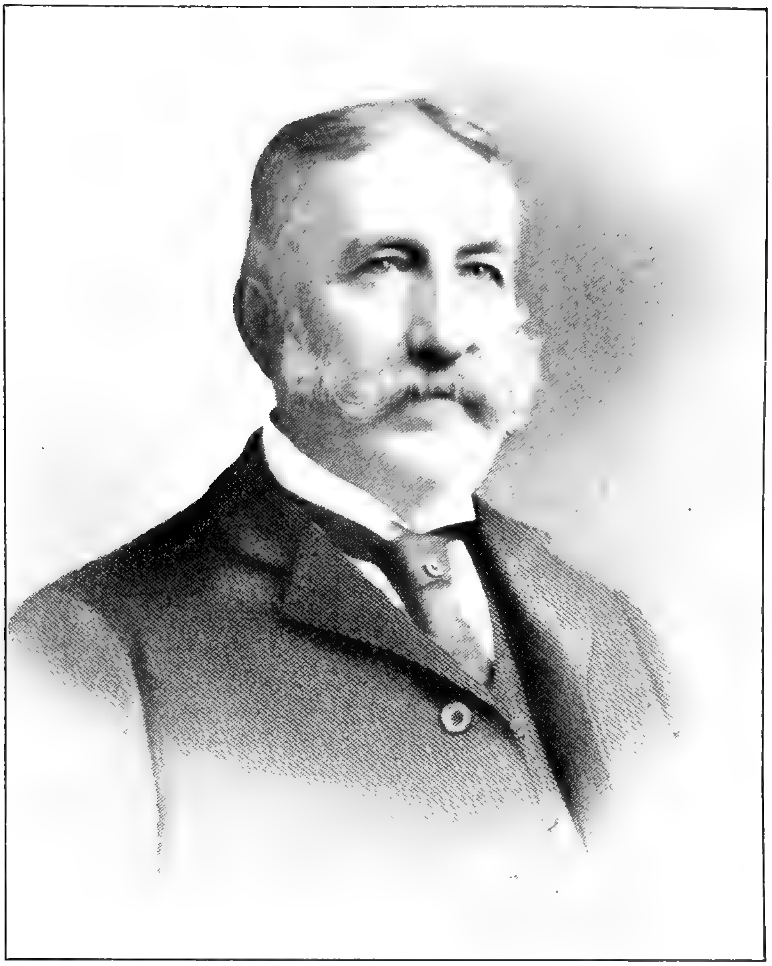
THE TELEPHONE IN CANADA

No record of electrical development in Canada would be complete which did not include the story of the telephone there.

It was at Brantford, Ontario, in 1874 that the thought came to Alexander Graham Bell as he experimented with a human ear:—"If sound waves beating against the membrane of the ear will move bones relatively so heavy, why will not a heavier membrane move a piece of steel."

"That was the thought," Dr. Bell has often declared, "that led to the invention of the telephone," and he adds, "It was here (at Brantford) the telephone was invented, the first draft of the patent specifications prepared, the proper relation of the parts of a telephone to enable it to be used on long lines marked out, and the first transmission of the human voice over miles of telephone line actually accomplished."

The first long distance line test in Canada took place in 1876 when Professor Graham Bell applied to the Dominion Telegraph Company for a permit to test his embryo telephone on its telegraph line between Paris and Brantford. When the formal application was received, the general manager of the telegraph company handed his assistant the letter with the remark, "Another of those cranks; consign it to the waste-paper basket." But the assistant, scenting a source of profit, suggested that the line be rented for an hour, which was done. Needless to say



THE LATE CHARLES F. SISE

Charles F. Sise, for over thirty years, was the outstanding figure in Canadian telephone interests. Born in the United States, he spent his early life on the seas, as his father was a leading merchant and shop owner. After commanding vessels in the Atlantic, Pacific, and Australian trades, he took charge of his father's cotton and shipping business in New Orleans, later going to England in charge of the Liverpool house.

In 1880, when the possibilities of the telephone were being demonstrated to the keen business minds of the country, Mr. Sise went to Canada and established the Bell Telephone Company of Canada and was connected with this Company as its president through all the days of its early development. He also organized auxiliary companies, and became interested in electrical affairs throughout the entire Dominion.

that the rental was never collected, as the talking, though possible but one way at that time, was successfully carried out, and it led to the Dominion Telegraph Company acquiring a license to operate the Bell telephone patent in Canada for a period of the five years from 18th February, 1879.

The first subscriber telephone contract secured in Canada was taken at Hamilton, Ontario, 18th of October, 1877, and the line, forming part of the local district telegraph call system, was equipped with six telephones and the first tested on the 29th of August, 1877. The press of the day announced that this was the first instance in which more than two telephones had been operated satisfactorily on one circuit. The opening of this line was attended by Professor Graham Bell, his father, Professor Melville Bell, and his uncle, Professor David Bell, all of whom expressed their surprise and delight at the successful operation of six telephones on one circuit.

The satisfactory talking qualities of this line immediately led to the opening at Hamilton of the first exchange in Canada, and the second in the world, by the Hamilton District Telephone Company on its call box circuits. The license to operate was granted on the 28th of May, 1877, and the first line opened on the 18th of October, 1877.

The Bell Telephone Company of Canada entered the field in 1880, and operated in all the provinces except British Columbia. That company purchased the various competing interests and consolidated the exchanges. But opposition was strong and in the early eighties some isolated Bell exchanges were threatened by demoralizing "Independent" competition.

The late Theodore N. Vail, who had been a director of the Bell Telephone Company of Canada from its inception, saved the day. After a brief study of the Canadian situation, he marked out on a map of Ontario and Quebec a plan of long line construction to various cities and towns within a radius of 300 miles of Montreal. "Build long distance lines at once to connect all the exchanges within this territory," advised Mr. Vail.

"But they will not pay," was objected.

"I did not say they would," replied Mr. Vail, "but they will unify and save your business."

And so it proved. The Bell Telephone Company of Canada, although withdrawing in 1908 from the Western provinces of Alberta, Saskatchewan and Manitoba, leaving the field there to the provincial governments, has developed a magnificent system that reaches all parts of Ontario and Quebec. On January 1st, 1920, it had 337,476 telephones in operation, and through its agreements for exchange of business with 720 local "farmer" or "co-operative" telephone organizations, it served an additional 105,587 subscribers' stations. It has over 80 substantial buildings throughout its territory, devoted exclusively to telephone purposes and it owns and operates 97,000 miles of long distance line, the whole system having involved an investment of over fifty-five million dollars.

THE TROLLEY IN CANADA

Some of the very earliest practical operation of street railways by electricity was done in Canada, due to the inventions and energy of Charles J. Van Depoele, a clever Belgian carver of artistic reredoses and church statuary. He was not only one of the founders of the great modern furniture industry of the United States, but one of the fathers of the "trolley." The record of his life and work is given very fully in the first volume of this "Story of Electricity.* Without repeating here that very interesting narrative, it may be noted that after trying out his crude overhead wire system at the Industrial Exposition in Chicago in 1883, he exhibited a short section of electric railway at Toronto, Ont., with a primitive underground or underrunning conduit system, which during the continuance of the Exposition carried about 200 passengers per trip, at a speed of about 30 miles an hour. In the Fall of 1885, Van Depoele again connected the horse car street railway lines with the exposition grounds, a distance of about one

* "The Story of Electricity," Vol. I, Chap. VI. "Story of the Early Electric Railway," pp. 105-107. Also "C. J. Van Depoele," p. 434.

mile; but this time an overhead trolley was used, using an underrunning trolley and trolley pole, making contact with the current-carrying wire, very much as modern trolleys do. But it may be mentioned that a little later on a street car line at Hamilton, Ont., Van Depoele had a trolley which made contact by running along the "top" of the wire, held in position firmly by a weight. The present writer owned one of these unique Hamilton trolleys for several years until it was unfortunately lost at sea with other exhibits on their way to the Paris Exposition of 1900, including Thomas Davenport's model electric car run by primary battery of A. D. 1834-40.

Returning to the Toronto line of 1885, which was a remarkably successful proof of what electricity could do, it may be added that the trolley stock consisted of a motor car and three trailers. There was only one track, but it had insulated track return, and the overhead feedwire was held up by brackets. The motor was on the platform or deck of the car, gearing downward with reduction to the car axles. Current was furnished by a Van Depoele arc light dynamo of 40-light capacity, driven by a Doty 10x16 steam engine. High speed was usually made, the train carrying 225-250 passengers per trip and an average number of 10,000 per day being hauled; the number being limited apparently only by the capacity of the rolling stock. Van Depoele followed up this demonstration with "real street railway" systems at Detroit, Mich., South Bend, Ind., etc., and it is not saying too much to assert that at Toronto were thus tried out the principles and apparatus that in a brief year or two made the Van Depoele "trolley" system widely known throughout the world, and helped lay the broad foundations of the modern "public utility" with its billions of investment and trillions of passengers.

In view of what has come later, it is seen that this, while necessary, as is all pioneer work, was but crude and prophetic, and needed other inventors with other ideas, refinements and improvements. In 1887, Lieut. Frank J. Sprague made his memorable installation at Richmond, Va., with 13 miles of track and 40 cars, under stipulation that at least 30 cars should be operated at once from the power plant; and in February, 1888, the brilliant achievement arrested universal attention. As shown above, Canada had already seen what Van Depoele could do, and now Mr. Thomas Ahearn of Ottawa was satisfied that with the Sprague system he could operate the whole street railway system of that city even under the severest winter conditions. From that magnificent demonstration, described elsewhere, doubting critics had no appeal; and the figures now given below tell how far the trolley has become domiciled and naturalized in the country that witnessed some of its feeble early struggles.

It would appear that for the year ending June 30, 1920, the statistics are as follow:

LENGTH OF LINES, MILES

	1918-19	1917-18
First main track	1,696.52	1,616.36
Second main track	482.36	453.11
Sidings and turnouts	220.92	206.57
Total	2,399.80	2,276.04

CAPITALIZATION

	1918-19	1917-18
Stocks	$93,042,368	$73,864,820
Funded debt	78,852,188	93,388,273
Total	$171,894,556	$167,255,093

EARNINGS, OPERATING EXPENSES, ETC.

	1918-19	1917-18
Passenger earnings	$32,826,609	$21,943,644
Freight earnings	2,045,303	1,575,408
Mails and express	162,703	129,317
Other car earnings	105,548	139,104
Miscellaneous earnings	545,417	512,424
Gross earnings from operation	$35,696,532	$24,299,889
Maintenance of way and structures	$2,792,258	$1,684,561
Maintenance of equipment	3,868,378	2,204,875
Operation of power plant	4,435	3,083,383
Operation of cars	11,801,071	7,810,063
General, traffic, superintendence, etc.	3,942,298	2,753,090
Total operating expenses	$26,839,070	$17,535,974
Net operating earnings	$8,857,461	$6,763,915
Miscellaneous income	2,723,510	2,311,176
Total corporate income	$11,580,971	$9,075,091
Taxes, interest, etc.	10,114,425	6,150,074
Total net income	$1,465,545	$2,925,017
Appropriated to reserve	$1,394,921	$1,466,339
Appropriated to dividends	1,508,716	1,671,352
Deficit	$1,437,091	$212,680

	1918-19	1917-18
Ratio of operating expenses to gross earnings	75.18%	72.16%
Fare passengers carried	686,124,263	487,365.45
Tons of freight hauled	2,474,892	2,497,530
Passenger car mileage	103,998,809	81,786,198
Other car mileage	2,962,798	2,649,125
Total car mileage	106,691,607	84,435,323
Equipment of all kinds	5,719	4,314
Employees, all grades	17,242	11,646
Salaries and wages	$17,210,851	$11,840,864
Accidents, all kinds—		
Killed	94	77
Injured	3,511	2,596

It would be difficult to give the exact figures of power plant employed to operate trolley systems in the Dominion for the reason that the same generators or power transmission systems are in many instances used also for lighting purposes and the supply of electrical energy for the operation of factories, etc. But the data given above, especially the rates of increase, show the trolleys of Canada to be enjoying at the time, a prosperity and progressiveness far beyond that of any other part of the world; and no good reason can be seen why such expansion should not be maintained.

ELECTRICITY IN THE GIBRALTAR OF THE DOMINION

Pivotal point in the great duel fought in the Seventeenth Century by England and France for mastery of the New World, Quebec has not only all the glory and glamour of splendid historical tradition around it, but has also the irresistible charm of noble scenery and the tremendous commercial attraction of a strategic point dominating the water-borne traffic between the Atlantic and Pacific oceans. It may be compared with many other notable cities of beautiful site, but will always remain unique and distinguished as the ages add other memories to those of Cartier, Champlain, Frontenac, Wolfe, and Montcalm, or witness the steady and stately development of its superbly rich, natural resources, even today almost virgin after three hundred years' occupancy by the two most vigorous colonising races of Western Europe.

With all its subtle old-world atmosphere and curious aloofness from some of the things on which modern civilization looks with pride, Quebec has in its recognition and adoption of such agencies as steam and electricity kept fully abreast of the times. As early as 1884, it was supplied with electric light by the old Quebec and Levis Electric Light Company. Two Thomson-Houston dynamos were operated by steam power in an old military barracks beneath the fortification walls adjacent to St. John's Gate. These were used to furnish current for series arc lamps, 9.6 amperes, placed in the stores, rinks, and other establishments.

It was a time, however, when the possibilities of hydro-electric generation and transmission were becoming recognized; and the opportunities presented at the famous Montmorency Falls, only about seven miles from the city, could not be overlooked. Thus one of the earliest of such plants was installed there under the unusually high head of 130 feet. The beautiful Montmorency River separates the parishes of Beauport and L'Ange Gardien and at the Falls makes a plunge of no less than 270 feet. From the top of the dam, which is in view from the adjacent trolley tracks, to the foot of the cataract is 274 feet, or 100 feet more than at Niagara.

In 1887 the city streets of Quebec were lighted with double-carbon series open arcs, current to which was supplied from 18 Thomson-Houston dynamos. In 1888 an attempt was made to operate incandescent lamps in multiple from the series circuits; but this interim method soon gave way to the alternating current system and apparatus. Two 100 kw, 1000 volt, single phase, 130 cycle generators were then installed, followed quickly by two others, and the electrical energy thus generated was transmitted to Quebec, the 1000 volts being there transformed; and the current was distributed at 52 volts, that low pressure being adopted on account of the prejudice then prevailing as to the dangerous nature of the alternating current even at so low a voltage.

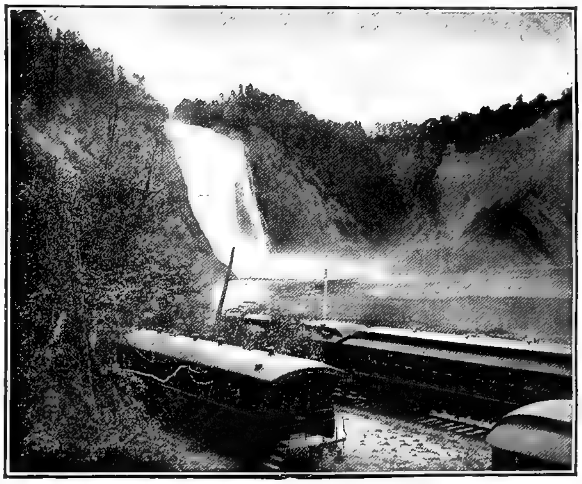
In 1893, the utility interests owning the

property changed its name to the Montmorency Electric Power Company, and in the following year, a new power house was built with a steel flume 6 feet in di-

Frontenac Hotel and Terrace, Quebec

ameter, and with a head of 170 feet. To this plant most of the Thomson-Houston dynamos were transferred. Three belted 600 kw., two-phase, 6000 volt, 66 cycle generators were also installed. These were the first machines of the type and voltage installed on the American continent. The current was transmitted at this pressure to the substation in Quebec, transformed to 2200 volts, and distributed on single phase lines for lighting. This pressure was again lowered to 110 volts for service connections and a 24-hour service was at once inaugurated. Circuits of 2-phase were run, and electrical energy was supplied to a large number of motors for commercial purposes.

About 25 years ago, to wit, in July, 1897, current was first supplied to the Quebec District Railway to operate its street railway system, by means of motor generators placed in the substation, in the city. In the same year, the three alternators were direct-connected to waterwheels of modern type; an additional 600 kw. alternator was installed in the Montmorency power house and the hydropower flume was carried as far back as the head of the Falls, furnishing a total hydraulic head of 190 feet; and a concrete dam 300 feet long was built, displacing the old wooden dam. As the two public utilities thus grew closer together and now depended upon a common source of power supply, a financial consolidation followed naturally upon the physical; and in 1898, the Montmorency Electric Power Company, the Quebec District Railway Company, and the Quebec, Montmorency and Charlevoix Railway were all amalgamated under the name of the Quebec Railway, Light & Power Company and the possibilities of the situation began to be rapidly converted into realities, such as the rehabilitation of the famous Kent House, once a residence of royalty and now a charming restaurant in the midst of a romantic park, an ideal pleasure retreat from the adjacent city and reached by elevator from the river and railroad level. A few miles further along the rich river valley is one of the most celebrated shrines in America, that of Ste. Anne de Beaupré, founded in the remote past of French Canada by some devout Breton sailors in gratitude for their salvation from perils of the sea. To that center of religious faith and veneration a steam railway ran, but in 1900 the line was electrified, witnessing since that time an enormous increase in traffic. A 600 kw. direct current



On the Route of the Quebec Railway

generator was installed at the Montmorency power house, and a 200 kw. motor generator at St. Anne de Beaupré, 14 miles away, to operate this division of the system.

Still another development came in 1907 when a further utilization of the abundant and splendid water power was made at the "Natural Steps" on the Montmorency River, about half-a-mile above the Montmorency Falls, with an initial capacity of 1500 kw. Moreover in 1909 an important improvement of a technical nature was made when the transformation system was changed from two-phase to three-phase, 23,000 volts, and "Scott connected" transformers were installed at Montmorency and Quebec.

A further step in the physical and financial relations of the local properties was taken in 1909 when a merger was carried out comprising the Quebec, Jacques Cartier Water Power Company, the Frontenac Gas Company, the Canadian Electric Light Company of Levis, P. Q., the Quebec Gas Company, the Quebec Railway, Light & Power Company, and the parent company, known as the Quebec Railway, Light, Heat & Power Company, Limited. The first-named corporation has a power-house 18 miles from Quebec City on the Jacques Cartier River, at Valcartier, with two 3-phase generators of 750 kw. capacity each, transmitting to Quebec at 23,000 volts, with a steam auxiliary in the city of three 350 kw. generators. The Canadian Electric Light Company has a hydroelectric development on the Chaudiere River, near Charney, with two 750 kw. and one 1000 kw. 3-phase generators which send their current at 11,000 volts 9 miles to a substation at Levis. Submarine cables across the wide St. Lawrence river connect the Levis and Quebec substations. From the Levis "sub" energy is supplied to the Levis County Railway, the Louise Dry Dock, largest of its kind on the American continent, and for all the requirements on the South shore of the St. Lawrence.

Main Office Building, Quebec Railway, Light and Power Co.

Nor is this all, for the Laurentian Power Company of Seven Falls, P. Q., also supplies under contract electric energy to the Quebec Railway, Light, Heat & Power Company's system. Seven Falls is approximately 35 miles distant from the old city of Quebec.

A Sight-seeing Car Typical of Canada

Some idea of the magnitude of the enterprise thus built up since 1884 around old Quebec, "cradle of New France," and today a key and gateway of Canadian development, may be formed from the fact that the gross earnings in 1919-20 reached a total not far short of $2,500,000. The officers of the company are Hon. Lorne C. Webster, president; Hon. D. O. L'Esperance, vice-president; Mr. W. J. Lynch, general manager, and Mr. Arthur Le Moine, secretary. The directors are all men well-known in the public life of the Province and the Dominion.

SOUTHERN CANADA POWER COMPANY, LIMITED

The Southern Canada Power Company, Limited, operates in that part of the Province of Quebec lying between the St. Lawrence River and the United States border. By the acquisition of several smaller properties, which have been linked together, the Company now furnishes light and power to some sixty municipalities in the district, as well as two in the northern part of Vermont, from its two hundred and forty miles of high tension transmission lines, fed from its power houses on the Magog, St. Francis and Yamaska Rivers.

The present capacity is fifteen thousand horsepower, but through ownership of other power sites on the Coaticook, Massiwippi, Yamaska, and principally the St. Francis River, its potential resources are in excess of one hundred and fifty thousand horsepower. Its power resources have been considerably enhanced by the conservation work of the Quebec Streams Commission on the St. Francis River, whose large storage dams on Lakes Weedon and St. Francis, control the flow of the St. Francis River.

The district has long been familiar with the benefits of electricity, as some of the municipalities served by the Company have been supplied from the earliest days of the industry. The original plant of the Richmond County Electric Company was installed in 1890; the original plant of La Cie des Pouvoirs Hydrauliques, at St. Hyacinthe, was installed in 1893; the original plant of the Brome Lake Electric Company, at Foster, was installed in 1894. These Companies now form part of the Southern Canada Power Company, Limited, which numbers amongst its employees one who has been in the continuous service of the property which it operates, for twenty-eight years, and several for over twenty-five years.

The Southern Canada Power Company, Limited, was incorporated in 1913, and has since acquired the following properties: South Shore Power & Paper Company, Limited; La Cie de Gaz, Electricité & Pouvoir (successors to La Cie des Pouvoirs Hydrauliques); The St. Johns Electric Light Company; Brome Lake Electric Power Company; Richmond County Electric Company and The Sherbrooke Railway & Power Company, with

its subsidiaries; Lennoxville Light & Power Company, Limited; Eastern Townships Electric Company; Stanstead Electric Light Company; Burroughs Falls Power Company, and the International Electric Company of Vermont.

The district served by the Company covers an area of approximately five thousand square miles, with a population of slightly over three hundred thousand. The transportation facilities within it are excellent, the district being traversed by ten railways, whose lines gridiron the area, so that there is no point more than ten miles from the "ironway." The population is largely French-Canadian, of the sturdy type that has contributed so largely to the industrial development of the New England States, and which is now contributing in the same manner to the industrial development of the homeland, where progress up to a few years ago had been retarded for lack of capital.

The capital needed for the new era is now assured. The industrial development of the last few years indicates the necessity of the rapid development of the water powers of the district, to keep pace with the demand. The district is exceptionally rich in natural resources, as in addition to agriculture, it has copper, timber and eighty per cent of the world's supply of asbestos. A great many American companies have crossed the border in the last few years to locate branch plants in the district, and judging from the increasing rate at which these American industries are locating, there is no doubt that a great many more will, in the near future, take advantage of the many opportunities offered.

The system of the Company is connected, for the purpose of ensuring additional power if and as required, with the systems of the Montreal Light, Heat & Power Company, and the Shawinigan Water & Power Company, which Companies serve districts adjacent to that being developed by this Company.

The standard electrical line methods throughout the system are uniformly three phase, sixty cycle, with transmission voltages: 48,000, 24,000 and 12,000;—distribution voltages, 2400, 600 and 120. There are no unusual construction features to speak of, with the exception, perhaps, of the fact that for over ten years the Company has been operating outdoor substations, and 200 feet span wooden pole transmission lines.

The record given above while complete and interesting in itself, does not reveal much of the underlying "human interest" that must attend every such pioneer development. Thus, for example, in speaking of the early days of the Richmond County Company, Lt. Col. J. W. Harkom remarks as to its experiences:—"Probably owing to lack of interest, the business languished and a fire occurred at the power station (used by the operator as a sash and door factory enabling the company to reduce his pay); thus putting an end to operations. An electric storm burned out an alternator, causing destruction to the whole building and contents, including an arc generator. This machine was a Thomson-Houston alternator built by the Royal Electric Company and believed to have been the first built in Canada. An application for fire insurance was prepared and held for three weeks for signature of the President, but was not placed before him." Need we wonder that the gallant Colonel, who cites a few other little illustrations of the perversity of things electrical heaves a sigh of relief, and says: "The writer looking back on the strenuous days above referred to, realises how little the present day plant suffers from many troubles which were difficult to combat, and is thankful that nowadays he is free from them."

In like manner in regard to the St. Hyacinthe plant, it is noted by Mr. George Pominville that in 1894 tests were made of the Oerlikon motors, of the famous Swiss make, probably among the very first of the kind installed on the American continent but some of which have remained in operation down to the present day "and have never had any repairs."

Another curious glimpse as to international relationships is afforded in the statement by Mr. A. W. Pettes, of Knowlton, as to the Brome Lake Electric Company's plant located at the outlet of beautiful Lake Brome: "This property was

originally owned by the Jones estate and had lain idle for many years, the heirs all living in England. Mr. W. S. Foster, of Richford, Vermont, conceived the idea of a lighting plant there, purchasing the property, consisting of 600 acres, October, 1894, installing a dynamo, using an old dam and mill for powerhouse, furnishing current for lighting Waterloo, five miles distant, also the village of Foster on the spot, later on furnishing the current for the Knowlton Electric Light Company at Knowlton." The Knowlton plant was later bought out and in 1901 the Brome Lake Electric Power Company was formed, and a new cement dam and power house were built lower down the river to develop the work.

THE OTTAWA ELECTRIC RAILWAY

The life work of Thomas Ahearn and Warren Y. Soper has been dealt with in two separate biographies, but there is a supplementary incidental chapter in the story of the Ottawa Electric Railway, which finds its fitting place here. Up to 1891 the young metropolis had to depend for urban transportation on a crude horse car service, between New Edinburgh and the Chaudiere Falls. It was, indeed, hardly a city, but a loose municipal union of four villages known as Upper Town, Lower Town, Sandy Hill and the Flats. It is freely admitted it was the coming of the trolley that made Ottawa. The civic authorities, aware of the necessities of the case, and believing a trolley system was the answer, offered a franchise to some Toronto financiers; also having it advertised in New York and Canadian papers. After some extensions of the time limit, the franchise was returned without acceptance by men who from long residence in those northern lattitudes had good reason to believe that no electric street railway could operate continuously in the realm of "Our Lady of the Snows." But at the psychological moment, Ahearn & Soper encouraged by their successes in electric lighting development came forward, volunteered to take over the discarded franchise, and put up a certified check for $5,000 as an evidence of good faith.

Before such courage, all obstacles dwindled away, and by June 29, 1891, the first trolley car ever operated so far north was running in Ottawa; the ensuing winter was more tolerant than had been hoped, and soon the new trolley régime began, with Montreal, Hamilton and Quebec following Ottawa's lead and other cities falling very quickly into line. The success of the Ottawa system has been beyond all cavil, and perhaps for a very good reason. As was said quite recently: "Messrs. Ahearn and Soper are thirty years older than when they piloted the first street car through the Capital, but they have been on the job all the time. They have had many interests to engage them as the years moved on, but it is no secret that the street railway is their first love to which their thoughts always turn." The management has, indeed, always been broad, liberal and progressive, and the attention to details is happily illustrated with the fact that the cars are all equipped with clocks, a convenience so very rare elsewhere on trolley lines, that Ottawans miss it very much when away from home. In spite of the expiration of the present franchise in 1923, the men who have operated it so admirably through three decades, evinced confidence in the continuing esteem of their fellow citizens by adding within the last few years a splendid new power plant at the Chaudiere under their own design and construction, modern in every item; and typical of the zeal and skill that first set the Ottawa cars in motion.

THOMAS AHEARN

THOMAS AHEARN

Few chapters in the electrical development of Canada compare in interest with that of the introduction of electric lighting, telephony and electric traction into Ottawa, national capital of the great Dominion; and of the personal fortunes of the firm of Ahearn & Soper so intimately and closely woven therewith. It is all one story springing from the adventures in modern enterprise of two young telegraph operators, who midway in the last century found opportunity awaiting them as it always attends those ready to dare bravely and do largely. Taking up the first named in the distinguished partnership, Thomas Ahearn, it may be noted that he was born June 24, 1855, in the city he loves and has done so much to serve, and in whose excellent public schools he was educated. In those early days he met Warren Soper, and the friendship thus formed first in boyhood games on the streets of Ottawa has continued through life. It was a time when the minds of ingenious boys with a mechanical turn were very much engrossed with the art of telegraphy, and nothing would satisfy this new Damon-Pythias team but a short telegraph line of their own, connecting their two attic windows. What did it matter if the respective homes were only a few blocks apart! Nor was it less than natural that this dabbling with the mysteries of electricity, and its crude initiation into the esoterics of the key should result in opening before both of the boys a brilliant career on a common pathway of achievement. In the good, old days of telegraphy, every budding operator worth his salt, may be said to have begun as a messenger boy, a deliverer of the messages he was so ambitious to transmit. 'Twas thus even with Andrew Carnegie himself. And then, joining the great fellowship of operators, young Ahearn and Soper found themselves members of a brotherhood which in this Western world has given a wonderful number of leaders in all departments of progress, many of whom have been their intimate friends. Perhaps that chapter of telegraphic history has closed, but it still includes many distinguished men. It has given America the great ironmaster; and the greatest inventor of his times in Edison. It has given Governors to several States, such as Cornell of New York and Bullock of Georgia. It has yielded many cabinet ministers to the United States, like President Grant's Postmaster General Marshall Jewell, and Cleveland's able Secretary of State, Daniel Lamont; or General T. T. Eckert, who was Lincoln's Assistant Secretary of War. As a master of Canadian development it sent forth Sir W. Van Horne; and other great railroad men have been prominent in W. C. Brown, president of the New York Central, or Marvin Hughitt, of the Chicago & Northwestern. In industrial and financial life we have had Theodore N. Vail, protagonist of the Bell Telephone System, and L. C. Weir, of the Adams Express; while in the telegraph field there have been such shining lights as Robert C. Clowry, president of the Western Union Telegraph, A. B. Chandler, president of the Postal, D. H. Bates, of the Baltimore & Ohio, George G. Ward of the Commercial Cable, E. J. Nally of the Marconi System. In literature there have been such spirits as George Kennan, Guy Carleton, Harry de Souchet, F. L. Pope, T. D. Lockwood, and James D. Reid, author of "The Telegraph in America." In journalism leading publishers and editors have been found in Frank A. Munsey, W. J. Elverson of the "Philadelphia Enquirer," and Edward Rosewater of the "Omaha Bee," W. J. Johnston, founder of the "Electrical World," and Dr. Robert Underwood Johnson, former editor of the "Century Magazine" and later U. S. Ambassador to Italy. Amongst such men as these Thomas Ahearn and Warren Y. Soper have held their own on even terms.

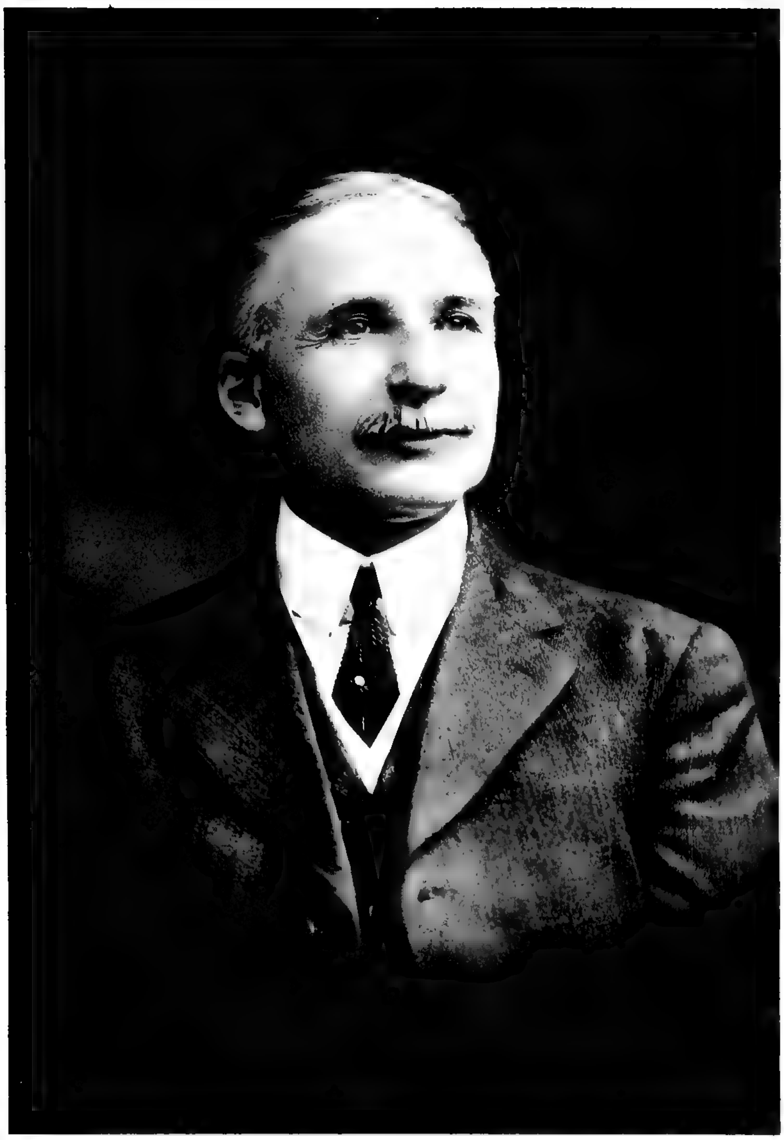
Mr. Ahearn after his start as Mercury in a branch office of the Montreal Telegraph Company at the Chaudiere, the Ottawa lumber district, soon made his way forward and became known, so that in 1873 having like so many operators of that time, begun his wanderjahre, he is

discovered as an employee at the old Western Union main office in New York at 145 Broadway, with the well-earned rating of a first-class operator. Four years later he had gone to the big new W. U. headquarters at famous "195." But just at this juncture came the epoch-making invention of the telephone, whose swift development claimed the best energies of so many telegraphers; and Ahearn was quick to see the new opportunity. In 1878 he took charge of the telephone department at Ottawa of the Montreal Telegraph Company, and thus was "in at the birth" of the new industry in Canada. In 1880 the present Bell Telephone Company of Canada was organized, taking over the then existing telephone systems; and Mr. Ahearn was at once appointed its agent at Ottawa with large powers and territory, being officially the manager of the Bell Telephone Company of that city.

But electrical history was making in other new fields also, and Mr. Ahearn, progressive, ambitious, courageous, was never the man to let any opportunity slip by, and he wanted to be in all of them at once, rather than limit himself to one field. He is indeed one of the few who have made their influence felt over the whole domain of modern applied electricity. His chum, Mr. Soper, being cast in the same mould, the inevitable step was taken in organizing the partnership of Ahearn & Soper, as electrical engineers and contractors, which dating from 1882, a notable year, has since then constructed and equipped some of the largest electrical plants and systems in the Dominion. In 1887, Mr. Ahearn severed active connection with the Bell Telephone System to devote all his time to the rapidly enlarging business of the firm; but always true to his early love he remained associated with it as Consulting Electrician, and in 1915 as a director.

Launching boldly in the field of electric lighting, Mr. Ahearn was in 1886 one of the founders of the Chaudiere Electric Light & Power Company, which was merged in the Ottawa Electric Company in 1895; this again, with the Ottawa Gas Company being absorbed by the Ottawa Light, Heat & Power Company. But while the electric light industry was getting on its feet, the trolley art was taking shape and demanding attention; so that in turn Mr. Ahearn was one of the founders and president of the Ottawa Electric Railway Company which solved the problem of operating in Canada throughout the long, severe winter a satisfactory street car service. And all this again led on to and included the development and utilization of the splendid water power which is one of the beauties and glories of the Canadian capital.

Such briefly is a most interesting, adventurous and successful career, ripe in achievement and still rich in promise. Mr. Ahearn is president of the Ottawa Investment Company, Ottawa Land Association, Ottawa Car Manufacturing Company, Ottawa Gas Company, Ottawa Electric Company, Ottawa Light, Heat & Power Company, Ottawa Traction Company, the Capital Mica Company, Ltd., vice-president Ahearn & Soper, Ltd., the Wallace Realty Company, the Ottawa Building Company; and director of the Canadian Westinghouse Company, Bell Telephone Company of Canada, the Merchants Bank of Canada, the Northern Electric Company, and the Bankers Trust Company. He is a member of the American Institute of Electrical Engineers, the Old Time Telegraphers' Association, and the Telephone Pioneers of America. His social tastes and activities are indicated by membership in the Rideau, Ottawa Golf, Ottawa Hunt, Laurentian, Rivermead Golf, and Mount Royal (Montreal) club. But while his home in Ottawa "Buena Vista," Laurier Avenue, is a center of hospitality, one is lucky to find him at home, for there was never a more inveterate globe trotter. It is a rare year when from some remote corner of the world, the friends of himself and the family do not receive details of fresh scenic wonders that the grand old "district messenger" has just brought into his sphere of observation.



WARREN Y. SOPER

WARREN Y. SOPER

Various references to the work and career of Mr. Soper will necessarily be found in the biographical sketch of his equally well-known partner, Mr. Ahearn, but it is needless to remark that such a life has had many individualistic features. Certainly the most striking is the fact that Mr. Soper has been among the Americans who have gone to the great Northland in early years and by their successes have so thoroughly identified themselves with the land of their adoption that it is difficult to realize that they are not natives. Mr. Soper was born in picturesque Oldtown, Maine, but he grew up in Ottawa where he arrived in his nurse's arms. His father and mother, Albert Webster and Eleanor (Young) Soper took kindly to life in the beautiful city, which, although now center of a vast Dominion, did not enjoy the prerogatives of a capital of old Canada until 1864; getting into the stride when the new federation was formed in 1867, at which time young Warren was barely 13, and a student in the Webster Institute.

Out of the juvenile telegraphic stunts engaged in with young Ahearn just about that time, as narrated elsewhere, came entry upon an electrical career, and at Ottawa, Mr. Soper began "pounding brass" to such purpose that he had soon risen from the ranks and had become manager of the Old Dominion Telegraph Company, entering a category including the many distinguished names mentioned in the Ahearn biography, and to which might be added here other such names as those of Hosmer, Erastus Wiman, and Messrs. Cox and Wood, and numerous other "brethren of the key" in Canada. But Mr. Soper had keen business aptitudes although he had already become superintendent of the Canada Mutual Telegraph Company, and at the age of 28, when in business for himself, he secured from the nascent Canadian Pacific Railroad a notable order for the telegraph instruments that were to govern the operation of that great system from the Atlantic to the Pacific. From that time onward the firm of Ahearn & Soper were leaders in the handling of telegraph apparatus in the Dominion, and many a concern would have been justifiably satisfied with the great electrical business thus developed. But it was into the larger field of public utilities that the young men projected themselves with striking results. In the telegraph field they were managers, but merely employees. Now they became "captains of industry," and creators of great enterprises of their own, giving work to thousands of fellow-citizens, establishing plants, founding central station systems, building hydraulic plants, establishing long transmission lines, and furnishing transportation, whose success has been in inverse ratio to the onerous conditions involved—as told in the brief history of the Ottawa trolley system.

The nature and scope of the multifarious enterprises that have received Mr. Soper's attention may be inferred from his present relationship as president of the following companies, viz.: Ahearn & Soper, Ltd., contracting electrical engineers; Dunlop Tire & Rubber Goods Company; Ottawa Building Company; Gas Accumulator Company of Canada, Ltd.; vice-president, Ottawa Traction Company; Ottawa Gas Company; and Ottawa Car Manufacturing Company; director, Ottawa Light, Heat & Power Company; Imperial Life Assurance Company; Canadian Locomotive Company; and director and member of executive committee, Canadian Westinghouse Company.

To this it may be added that Mr. Soper is a member of the Rideau, Ottawa Hunt, Ottawa Country, Mount Royal (Montreal), York and National (Toronto), Rivermead Golf, Ottawa, and president of the Royal Ottawa Golf Club.

He was married in June, 1881, to Annie Newsom, and has three sons and a daughter. His residence is Lornado, Rockliffe Park, Ottawa, where advantage has been taken for the systematic and energetic enjoyment of intellectual tastes and the cultivation of artistic interests. Had Mr. Soper not become so deeply immersed in business, Canadian letters would have been the richer for his work in authorship.

LT.-COL. D. R. STREET

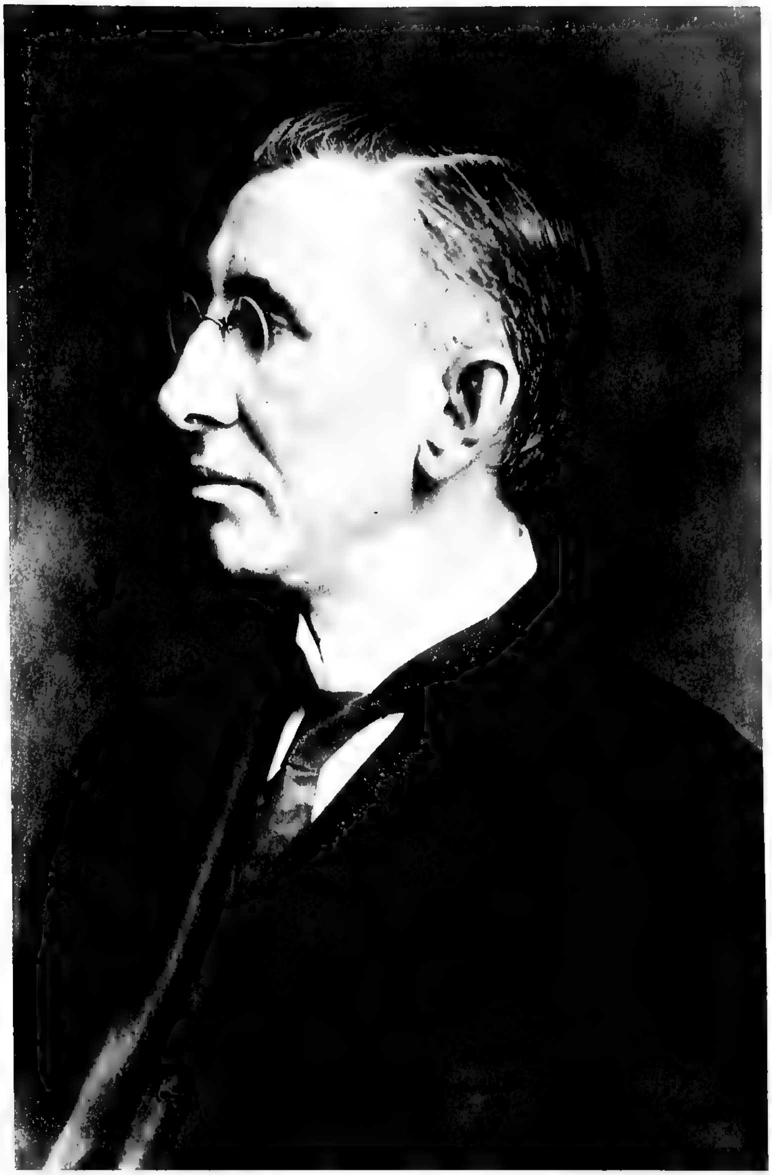
An Ottawan closely identified with the growth of the public utilities of the city is Lt.-Col. Douglas Richmond Street. He was born at Fredericton, N. B., June 19, 1864, and is grandson of the late Hon. J. A. Street, K.C., Attorney General of the Province of New Brunswick, and son of C. F. Street, M. A., and Lucy Audubon (Kendall) Street. He was educated in the separate schools of Ottawa and at Ottawa University. His various official connections through a long and active career may be summarized as follows. Division chief accountant and paymaster of construction, Cape Breton Division, International Railway Company of Canada; secretary-treasurer, Chaudiere Electric Light & Power Company, director and secretary treasurer of the Ottawa Gas Company, the Ottawa Light, Heat & Power Company, and the Ottawa Electric Company; director of the Capital Trust Company of Ottawa and director of the Capital Life Assurance Company of Canada.

But it is at least as a leading Canadian soldier that Col. Street is known throughout North America. He has long been connected with the Canadian Militia, being gazetted 2nd lieutenant, Governor General's Foot Guards, 1893, Lt.-Colonel commanding, 1908, and commanded the regiment during the Quebec Tercentenary celebration 1908, and at Plattsburgh, 1909. He commanded the 77th Overseas Battalion, C. E. F., which he organized and trained, taking it to "Flanders fields" for the Great War in June, 1916. He is now officer commanding the Eighth Infantry Brigade, M. D., No. 3, to which duties he brings a training and experience almost without equal in his own country.

He married Elizabeth Bauld Christie, daughter of John H. Christie of Bras d'Or, C. B. Before going abroad on active service, he was for three useful years president of the Canadian Electrical Association and since return he has been elected vice-president of the Canadian Gas Association. He is a member of the Rideau and Royal Ottawa Golf clubs; and the Ontario Motor League.

A. A. DION

Born at Quebec, P. Q., in 1860, and educated there, Mr. A. A. Dion is a highly typical representative of the best French-Canadian inheritance and tradition. Becoming a telegraph operator when only 15-16, with the Dominion Telegraph Company, and then electrician for the Dominion Government Intercolonial Railway, his passion for physical science soon led him from early interest in telegraphy and train signaling into the new branches of electrical application. For many years past he has been prominently associated with the great public utilities of the Dominion and with the engineering management of the properties at Ottawa, which has the very distinct honor of being the first city on the American continent to make a contract for the entire electric lighting of all its streets. First as general superintendent of the pioneer Chaudiere Electric Light & Power Company, and up to the present time, in administering as general manager and director of the Ottawa Electric Company, the Ottawa Light, Heat & Power Company, and the Ottawa Gas Company,—Mr. Dion has watched and applied in his own important territory all the successive inventions and improvements in the lighting, heating and power arts, and his success may be gauged by his past presidency of the Canadian Electrical Association, the Canadian Gas Association, and his long prominence in the National Electric Light Association. He is also a member of the British Institution of Electrical Engineers, of the Engineering Institute of Canada, a Fellow of the Am. Institute of Electrical Engineers, a member of the Illuminating Engineering Society, and of the American Metric Association. He is also a member of the Dominion Good Roads Association, the Ontario Motor League, and of the Laurentian, Rivermead, and Hunt and Motor clubs of Ottawa, and a Councillor of the Ottawa Board of Trade.



JOHN MURPHY

JOHN MURPHY

Born December 17, 1868, and educated in Ottawa, Canada, Mr. John Murphy graduated from the Science Course at the College of Ottawa in 1884 and took up his life work so immediately thereafter that he has been continuously connected with the evolution and development of all the great modern electrical arts in the Dominion. To real practical experience he owes his intimate acquaintance with the technical details of telephony, electric lighting, electric railway work, power transmission, etc.

While Ottawa has always been his home, he has traveled extensively and has superintended work in many parts of Canada. He has the "convention habit" well developed, and from the earliest days of the electrical industry has attended national and international engineering meetings and has inspected many pioneer enterprises. His later connection with the Dominion Federal Department of Railways and Canals, and with the Board of Railway Commissioners has brought him in contact with an endless variety of complicated problems, whose study and solution has tended to broaden his earlier experience and place him in personal relations with the officials of all electrical and railway organizations founded or operated under Federal charters.

As a Conservationist, he has achieved considerable success, and during the World War did noteworthy work in securing power for the manufacture of munitions, besides accomplishing some praiseworthy results in the saving of coal by the substitution of hydroelectric energy during the coal shortages. His well known studies of "anchor" ice and "frazil" problems, carried on as a side issue, have given the engineering world new light on these subjects. During the past few years he has, for instance, with the aid of lantern slides and unique moving pictures done much to educate the public and his professional confrères to the fact that these forms of ice, when understood and handled properly, need not be a menace to the uninterrupted operation of water plants, as hitherto has been supposed to be the case. This is a genuine and notable service to his country, whose future not less than the present, is based upon the utilization of almost illimitable waterpower resources.

Mr. Murphy, who is consulting engineer and hydro-electric expert of the Canadian Government, is a Fellow of the American Institute of Electrical Engineers, and Member of the Engineering Institute of Canada, American Electric Railway Association, Canadian Electric Association, Illuminating Engineering Society, and the Railway Signal Association.

THE LATE HON. FREDERIC NICHOLLS, J. P., F. R. C. S.

Lt. Col. The late Hon. Frederic Nicholls, born in England, Nov. 23, 1856, and educated there and at Stuttgart, Germany, was a notable member of the group of "Imperial Englishmen" who, during the second half of the Nineteenth Century, were intimately and indissolubly associated not alone with the expansion of the Empire itself but with the development within it of great new nationalities, commonwealths and Dominions, and the foundation also within its borders of the various fundamental enterprises and utilities upon which modern civilization is based. It is a curious fact in political history that during the first half of the last century no sentiment was more general in the "old country" than that of "letting the Colonies go"; but during that very period the new forces and new men were in preparation for the new era, to which belong the greatest achievements of the English-speaking race and the records of such personalities as Cecil Rhodes, Lord Strathcona and the subject of the present brief sketch.

Young Nicholls was not quite of age when he landed on the shore of Canada in 1876, nor were his resources any larger than his years; but such courage, energy and ability as his would score in any progressive country. It was, however, fortunate for electrical development in his adopted country that he was swift to visualize the possibilities of the new arts of electric light and power. It was the dawn and beginning of Canadian manufacturing, when the young Dominion passed from the ranks of a provincial producer of mere food and raw materials, and instinct with new-born nationalism insisted upon a place among manufacturing peoples. The boundless Canadian West had not yet opened up, for as late as 1896 there were only 1800 homesteads taken up west of the Great Lakes; but the human tides were flowing from Europe through the portals of the St. Lawrence, and the future was outlining itself to watchful eyes. No man was closer associated with that birth of Canadian industries and engineering or had remained nearer to it through all the long intervening eventful period than Senator Nicholls. Not only was he secretary for seven years of the powerful Canadian Manufacturers' Association, but he founded the "Canadian Manufacturer," then the official organ and spokesman of the manufacturing interests, of which he was editor and proprietor down to 1893. He also served as Consul for the Kingdom of Portugal, but as will shortly be noted he soon flung himself heart and soul into electrical manufacturing, and with characteristic energy created thus one of the greatest enterprises of the kind over which a British flag has ever flown.

Going back a little in our story, it may be noted that in December, 1888, Mr. Nicholls called together a number of prominent citizens of Toronto and organized a syndicate to establish an electric light and power plant, virtually based on the Edison system, and thus founded the first company of its kind in Canada, if not indeed in the Empire, with underground wires and cables. The initial project was modest enough, for the ten underwriters put in only $1000 apiece, but the outgrowth has been extraordinary.

First of all there has been the creation of one of the great city central station systems of the continent, that of Toronto itself; and a consequent development of that came in 1903, at the hands of a syndicate of these men, of whom of course one was Mr. Nicholls—the utilization on the Canadian side, of the power of the great Cataract, 70 miles away from Toronto. A concession for the generation of no less than 125,000 electrical horsepower was granted to the Electrical Development Company of Canada with a capital of $6,000,000, and then a second corporation, the Toronto and Niagara Power Company, was organized to transmit that power to the northern portals of the Queen City, there to feed into the circuits of the substations and systems of both the Toronto Electric Light Company and the Toronto Railway Company.

Just before the Great War, the other

FREDERIC NICHOLLS

part of the enterprise, which soon grew by natural evolution into the Canadian General Electric Company, Limited, celebrated the twenty-fifth anniversary of the organization of the little syndicate, and Mr. Nicholls was able at that time to state that the modest \$10,000 had swollen into assets of \$25,000,000, that dividends of \$6,286,744 had been paid, that a surplus equal to nearly 40 per cent of the paid-up capital had been accumulated, that the average cash received per share common and preferred had been \$118, and that the common stock then represented a value of \$140 per share. Even the most grudging critic of the finances of electrical development must admit that such a showing redounds to the infinite credit of those responsible for it.

Early in 1891 came this "splitting of the circuit" and the bifurcation or differentiation of enterprises, distinguishing between the use of electrical apparatus and the manufacturing of it. The initial business of the Toronto Construction & Electrical Supply Company as distinguished and separate from that of the public utility, the Toronto Electric Light Company, was simply the sale of electrical apparatus and supplies; but far larger plans and intentions were in mind than that, and thus, told very simply, there soon came a merger which in the Canadian General Electric Company paralleled very closely the events which the United States also saw about the same period—the union of the great leading electrical manufacturing interests. What happened is perhaps best told in the simple terse statement of President Nicholls, as head of the Company, on the twenty-fifth anniversary of the enterprise that itself, like Canada, had thus grown so immensely in the quarter century. He said: "The business of the Toronto Construction and Electrical Supply Company was the sale of electrical apparatus and supplies, and soon after its incorporation, on the 14th of October, 1891, it formed an alliance with the Thomson-Houston Electric Company of Boston and entered into an agreement to act as their sole agents for Canada. From the start this company was very successful, and secured in a short time such favorable recognition from the purchasing public that negotiations were entered into for the purchase of all the Canadian property and interests of the Edison Electric Light Company, including their factory at Peterborough, the Thomson-Houston and Edison interests in the United States having in the meantime been merged into the General Electric Company. After some delay in the negotiations, an agreement of purchase was concluded, and the Canadian General Electric Company was organized on the 5th of Sept., 1892, so that the Canadian General Electric Company which was the outcome of the original investment of \$10,000 by the syndicate of ten has some time since attained its majority."

Thus began a chapter of Canadian General Electric history unsurpassed anywhere as a record of expansion and closed, perhaps, with the outbreak of the Great War only to find its sequel in another chapter and period coinciding with the present third decade of the century. The Edison and Thomson-Houston interests acquired were conjoined with those of the other famous parent systems—Brush, Fort Wayne, etc.—to which year by year under Mr. Nicholls' masterful and untiring direction were added other proprietary rights and manufacturing plants so that factories and agencies, while offices were needed and established all over the Dominion, and very few branches of industry were left untouched. Products so diversified were turned out as dynamos and motors, bridge and structural steel, architectural bronze and iron, mining and milling machinery, street cars and electric locomotives, arc and incandescent lamps, transformers and insulators, carbons and storage batteries, wires and cables, electric porcelain and fixtures. Nor was this all, for as well as producing this various material, Mr. Nicholls had ever been keen to create new markets for its consumption; and public utilities that owe their very existence to his initiative or fostering care, now flourish wherever the maple leaf flag waves. Trolley systems not less than electric lighting plants, hydro-electric development equally with the electrification of steam railways and terminals, mills and mines, are but items in a long list of his successful achievements. Nor was there any intention to rest satisfied with the things done.

As Mr. Nicholls has said: "There is no reason why we should not expect a satisfactory growth in the demand for our products. . . . A normal growth of population may be counted upon. The trunk line railways will undoubtedly electrify certain sections, such as terminals and mountain divisions. . . . In considering the future uses of electricity in Canada, we must bear in mind the impetus this industry has received as the result of a utilization of our magnificent water powers. Few realize that from Quebec in the east to Victoria, B. C., in the west, nearly every city, town and village has the advantage of hydro-electric power for its lighting, its street railways and its industries. Quebec, Montreal, Ottawa, Toronto, London, Port Arthur, Fort William, Winnipeg, Calgary, Vancouver, Victoria, and intermediate points are all operating electrically, and our reserves of water powers undeveloped will serve the needs of our country beyond our time." This language is that of a far-sighted leader—for it was spoken many years ago.

It is significant but natural that not less than 25 years ago, Mr. Nicholls was elected president of the National Electric Light Association, being indeed the only Canadian citizen who has ever held that prominent position, to the duties of which he brought unflagging devotion, visiting New York very frequently, almost weekly. This may serve to typify his public relationships; but they have been very numerous and fall into several categories. Reference has already been made to his work as a protagonist of the policy of protection under which Canada has built up her industries, and to his activities as a publisher and editor.—Taking first his business relationships, it may be noted that he was Chairman of the Canadian General Electric Company, President of the Canada Foundry Company, Ltd., Canadian Allis-Chalmers Company, Canadian Sunbeam Lamp Company, Canadian Radio Corporation, Ltd., Canadian Edison Appliance Company, Ltd., Marconi Wireless Telegraph Company; vice-president, Dominion Coal Company, Dominion Iron and Steel Company, Electric Development Company of Canada, São Paulo Tramway, Light & Power Company, Toronto and Niagara Power Company, Toronto Railway Company, Toronto & York Radial Railway Company; director, British-American Assurance Company, Confederation Life Association, U. S. Fidelity & Guaranty Company, Toronto Electric Light Company, Toronto Suburban Railway Company, Western Assurance Company.

Service and distinctions on the political and social side are not less impressive. Mr. Nicholls at the very outbreak of the war was gazetted an honorary Lieutenant-Colonel, October 17, 1914, and during the long struggle occupied several useful positions such as member of the Executive Committee of the General Council of the Canadian Patriotic Fund, vice-president and chairman of the Executive Committee of the Toronto Branch of the Canadian Red Cross Society, and president of the Toronto Municipal Loan Association, a society formed to relieve distress. In 1917, on January 20, he was appointed a member of the Senate. Education had also appealed to him, and he was not only vice-president of the Board of Endowment and Finance, Trinity University, but a director of the Ridley College. In 1890 he was president of the Toronto Press Club, and in 1893 president of the Athenæum Club; he was an honorary member of the National Electric Light Association, and the Canadian Press Association, and a life-member of the Toronto Board of Trade; chairman of the Senate Standing Committee on Finance, and vice-president of the Canadian National Institute for the Blind.

All this was supplemented by club memberships which reveal a wide range of social interests, including such sports as hunting, golf, yachting, motoring and fishing, and Senator Nicholls was well-known for his efforts to uphold Canadian supremacy in the motor boat sport. His clubs were the York; Toronto; Toronto Hunt; Albany; Engineers'; Ontario Jockey; Rosedale Golf; Toronto Golf; Scarborough Golf and Country; Hamilton Golf and Country; Royal Canadian Yacht; Mount Royal (Montreal); Rideau (Ottawa); Lambton Golf and Country; Country, Ottawa—of all of which he was an influential member.

SHAWINIGAN WATER & POWER COMPANY, SHAWINIGAN FALLS, P. Q.

Among the scenic beauties of Eastern Canada, the falls at Shawinigan have always been considered one of the finest and grandest displays of thundering water and rising spray. Even today, after men have tamed this offspring of the Laurentians and have turned its great force to the use of mankind, these falls during the spring and early summer still maintain the beauty and grandeur of former days.

This part of the country was some forty or fifty years ago a meeting place and "happy hunting ground" of the Indians, and the Indian name "Shawinigan," which means "beautiful quill and bead work," expresses the similarity of the glittering waters to the iridescent beads and pearls of the Red Man.

These falls are located about twenty-two miles from the mouth of the St. Maurice River, a tributary of the St. Lawrence River, entering at Three Rivers, a town about equally distant from the cities of Montreal and Quebec. The St. Maurice River just above the falls flows calmly among several islands, then suddenly the waters rush in a series of cascades forming a mighty stream tumbling and whirling around in a foaming torrent and forcing its course through a rocky gorge into a calm wide bay.

Some twenty years ago, at the beginning of the hydro-electric era, courageous and far-seeing men conceived the idea of making use of the energy of the Shawinigan Falls. To carry out this project, the Shawinigan Water & Power Company was organized and a charter obtained in 1898. The next year the power development was started by building the canal and power house containing the first two units of 5000 hp. At that time the Company started to furnish hydraulic power to the first two industries located at Shawinigan, namely, the Northern Aluminum Company and the Belgo-Canadian Pulp & Paper Company. These two concerns used then about 15,000 hp.

In 1902 the first electrical energy was delivered to the Shawinigan Falls Terminal Railway Company, an undertaking organized to handle freight between the railway terminals and the industrial plants.

The following year saw the putting into service of the first high-tension transmission line operating at a line pressure of 50,000 volts, with a capacity of about 7,000 kilowatts, running from Shawinigan Falls to Montreal. This was the second 50,000 volt line put in operation on the American continent.

About this time, electrical energy commenced to be used at Shawinigan Falls in the manufacture of carbide. This electro-thermic industry has grown to be a very important undertaking, and is now entirely controlled by the Company. Originally, carbide was used to produce acetylene for illuminating purposes, but today it has its main use in oxy-acetylene welding and the cutting of metals, and in the production of synthetic chemicals from the acetylene gas.

The electric power plant at Shawinigan containing the two 5000 hp units generating 30-cycle current was not equal to the demand, and as the transmission system of the Company grew, additional unit capacity had to be added until in 1909 there were three 9000 hp units and three 11,000 hp units in operation.

The provision of this additional power made possible further extensions to the transmission system, and another 50,000 volt line to Montreal and lines supplying the Asbestos Mining District at Thetford Mines and Black Lake were built, besides a number of smaller lines taking care of the general growth of the power demand in the district between Three Rivers and Montreal.

Two 50,000 volt lines to Montreal had a combined capacity of about 25,000 hp. At the Terminal Station No. 1 in Montreal, the voltage of 50,000 was stepped down to 2200 volts and the frequency changed from 30 to 60 cycles, this latter frequency being that which was employed in the city of Montreal by the Montreal Light, Heat & Power Company, which

had become one of the largest customers.

By 1909, the largely increased demand for power forced the management of the Shawinigan Company to consider the installation of additional capacity, and it was thought advisable not to extend the existing power house but to build a new plant in which all the latest improvements could be embodied and the highest efficiency of apparatus attained. This work was carried out in two stages:—1. The extension to the forebay and gatehouse was carried through for five additional units in the new power plant. 2. The construction of Power House No. 2 with five units of a total capacity of 90,000 hp.

Each unit is separate from the intake, with its own penstock, turbine, generator and transformer, working under a total head of 150 feet. The generator voltage of 6600 volts, 60-cycle, is stepped up to 100,000 volts and transmitted over a double circuit tower line to Montreal to the No. 2 Terminal Station, and there stepped down to 12,000 volts for general distribution in Montreal.

All the local hydraulic improvements on the St. Maurice River could not, however, improve the flow condition during the winter to any considerable extent, and it was therefore deemed advisable to inaugurate a storage scheme in the upper regions of the St. Maurice River, where the Manuan River storage by building dams was created. This storage proved sufficient to increase the minimum flow at Shawinigan Falls from 6000 to 8000 cu. ft. per second.

In 1914 the Government of the Province of Quebec, becoming interested in the conservation of hydraulic power, undertook the erection of a large concrete dam on the St. Maurice River, fifty miles from the nearest station on the Transcontinental Railway, and two hundred miles from Shawinigan Falls. This dam, completed in 1917, is impounding more than one hundred and sixty billion cubic feet of water in a large number of lakes and is equipped with gates to regulate the flow of the St. Maurice in such a way that the minimum flow at Shawinigan can easily be kept around 14,000 to 15,000 cubic feet per second. With this improved condition of the St. Maurice River, the Shawinigan Company will be in a position to add materially to their power plants at Shawinigan Falls, and it has been decided to install additional generator capacity in an extension to the present No. 2 Power House. For the present, one unit of 40,000 hp is contemplated and should be available for operation early in 1922. To transmit this additional power, an additional 100,000 volt tower line from Shawinigan Falls to Montreal is under construction.

The increased amount of power developed at Shawinigan Falls made it necessary to improve the flow conditions of the St. Maurice River by building a system of movable gates at Shawinigan Falls just above the falls, allowing the level of the river to be raised about 10 feet above the former average water level, at the same time creating a certain local storage. This work was carried out soon after the new power house was put in operation.

The power transmission system was extended to reach the cities of Quebec and Sherbrooke. The power demand on the south shore of the St. Lawrence River grew to such an extent that the submarine cables at Three Rivers, forming the link in the transmission line, were replaced by an overhead crossing, spanning the St. Lawrence River for a distance of 4,600 feet, supported by steel towers 375 feet high. The three steel cables acting as messenger cables are carrying two transmission circuits designed for 100,000 volt operation, but are used at present only for 60,000 volt.

Seven miles above Shawinigan Falls, the Laurentide Power Co. built a hydroelectric power house with six 20,000 hp units, which can be brought up to nine units eventually. The Shawinigan Company in 1916 entered into a contract with the Laurentide Company whereby the former purchases all the power of this development in excess of 37,500 hp reserved for the purpose of the Laurentide Company for the manufacture of pulp and paper.

Electrical energy is sold to a great number of large power users, as well as to several private distribution companies and to a number of distributing companies con-

JULIAN C. SMITH

trolled by the Shawinigan Company, such as Laval Electric Company, North Shore Power Company, Electric Service Corporation, Public Service Corporation of Quebec, Continental Heat & Light Company and the Three Rivers Traction Company.

The total mileage of all the transmission lines of high and low voltage is more than 1,500 miles, serving a territory of about 20,000 square miles with a population of one and a half million in more than one hundred and fifty municipalities. The total hydraulic and electric power generated and distributed by the Company in 1920 will be in excess of 1,200,000,000 kilowatt hours. Summarizing, the installed capacity in electric generating equipment owned or controlled by the Shawinigan Company is as follows:—

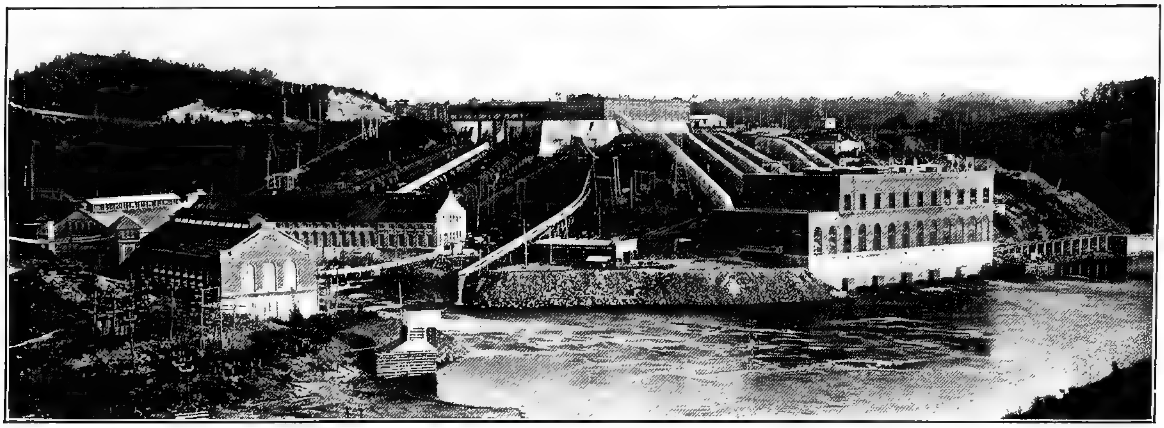
	hp
Shawinigan Plant No. 1	58,500
" " No. 2	100,000
Laurentide (120,000 hp installed)	82,500
St. Narcisse ditto	1,200
Steam Plant of Quebec City Public Service Corporation ..	4,000
Total electric capacity	246,200
Hydraulic power supplied	50,000
Total	296,200

The total development, present and future, from power sites controlled by the Company can be summarized as follows:—

	H.P.
Electric equipment now installed	246,200
Hydraulic power supplied	50,000
Future provision at Laurentide Company	60,000
Future additional development at Shawinigan Falls	100,000
Future development at Gres Falls	150,000
Total	606,200

of which 296,200 hp is now installed as Hydraulic and Electric power, leaving 310,000 hp for future development. The latter figure, however, is not to be considered as a final possibility of power development as there are hundreds of thousands of horsepower on the St. Maurice River waiting to be developed and which may in future be connected up with the Company's power system.

The Shawinigan Company's business has not been confined solely to generating and distributing electric power, but as above mentioned it has been extended along manufacturing lines by the acquisition of the carbide plant at Shawinigan Falls, now known as the Canada Carbide Company. In this way an outlet for power has been created which will help the Company to maintain a high load factor on its system and to use electric power which might otherwise not be profitably sold.



Shawinigan Water & Power Company, Shawinigan Falls, P. Q.

The operation of the carbide plant depends very much on a steady supply of large carbon electrodes and it was, therefore, deemed advisable to manufacture these electrodes at their Shawinigan plant. This called for an additional industry and the Canadian Electrode Company was formed to produce such electrodes for the Carbide Company and for other electric furnace plants at Shawinigan.

Whereas carbide up to recent years was used for illuminating and welding purposes, it has been found that acetylene gas made from carbide is the starting point for the production of a number of synthetic organic compounds. The manufacture of such products from acetylene was brought about by the exigencies of the war, and in this way the Shawinigan Water & Power Company undertook the manufacture of such products as acetaldehyde and acetic acid in large quantities in the plant of their subsidiary company, the Canadian Electro Products Company.

This latest undertaking in the industrial line will no doubt prove the nucleus of a large chemical industry at Shawinigan Falls and serve at the same time as a desirable outlet for large amounts of electric power.

Generally speaking it will be seen that by reason of the large water powers conveniently located considerable electrical development has taken place in the territory served by this company. The future looks very bright for the rapid increase in the amount of power used by reason of new industries of many and varied nature coming into the Province from nearby provinces and from the United States.

Fortunately there is in sight an almost unlimited capacity of water power sufficient for great future requirements, and in addition there is also a large population from which can be drawn skilled and contented workers.

By reason of the high cost of fuel at the present time, generally speaking, hydroelectric power compares very favorably with that generated by steam, and in that is found a favorable factor for increase in the use of such power in the Province of Quebec.

Transportation is well taken care of, the territory being served by the Canadian Pacific Railway, the Canadian National Railways and the Grand Trunk Railway, extensive ocean transportation being within a few hours' reach either at Montreal or at Quebec City.

EUGENE F. PHILLIPS ELECTRICAL WORKS LIMITED

MONTREAL, CANADA

The firm of Eugene F. Phillips Electrical Works Limited was founded in 1889 by the late Eugene F. Phillips of Providence, R. I., one of the pioneers of the Wire and Cable industry on the American Continent, who in 1870 laid the foundation of the American Electrical Works in Providence, R. I., and was one of the first manufacturers of insulated wires and cables. At that time the transmission of electric power had not been developed to any appreciable extent, and as far as insulated wires were concerned it was to the manufacture of wires and cables for telegraph and telephone purposes that this company devoted their energy and attention.

By 1889 the demand for telephone cables had increased to such an extent that Mr. Phillips decided to erect and operate a manufacturing plant in Montreal to supply the requirements in Canada. As a consequence of this the Eugene F. Phillips Electrical Works Limited was formed and a plant laid down on the Lachine Canal at Point St. Charles, Montreal.

For many years a thriving industry was carried on at these works in the manufacture of bare copper wires and cables, weatherproof wires and cables, magnet wires, flexible cords and telephone cables; the copper rod from which these wires were drawn being brought to Montreal from the American Electrical Works, where a copper rod rolling mill had been erected.

The business in Canada developed to such an extent that by the year 1904 it was found necessary to extend the plant, and a new site was selected at Mile End, Montreal, where a factory was erected which was estimated at that time to be of sufficient capacity to handle all the prospective business for many years to come. At this plant, starting operation early in 1905, equipment was installed for the manufacture of all classes of bare copper wires and cables, magnet wires, rubber insulated wires and cables, flexible cords, telephone cables, etc.

LAWFORD GRANT
Managing Director, Eugene F. Phillips Electrical Works Ltd.

Mr. Phillips did not live to see this factory in operation, his death occurring in 1905 at the age of 62. The business then passed into the hands of the two sons, E. R. Phillips and F. N. Phillips, the latter assuming the position of President and the former the position of Vice-President, which positions are held by them to this day. The active management of the business is in the hands of Mr. Lawford Grant, the Managing Director and Treasurer, who was formerly President of the Canadian British Insulated Company in Montreal, and whose experience covers many years previously with the British Insulated & Helsby Cables Limited in England, who were the first company in Great Britain to manufacture paper-insulated power cables.

In the electrical industry, copper plays a very prominent part, and the forms in which it is used are very numerous, while

the methods of insulating wires and cables are of many varieties. There is probably no industry in which a greater diversity of product is offered than the manufacture of bare and insulated copper conductors. The wire may be as small as 1/1000th. of an inch in diameter, and may have an insulating covering of the finest silk; or the cable may consist of several heavy copper conductors insulated with paper and covered with lead and armored with steel tape or wire, with a finished diameter of over 6 inches. A bare copper conductor may be a thin filament for some delicate electrical instrument or a set of heavy flat bars for a power station to carry many thousands of horse-power of electrical energy; and when it is considered that each individual conductor may be solid wire or stranded cable, round, square or flat, hard, soft or medium, bare or insulated in a multitude of different ways, it is readily seen what an infinite range of product is covered. Taking only one single method of insulating, the conductor may be protected by a covering to withstand only 2 or 3 volts pressure, while to-day 44,000 volts insulation is becoming a common requirement for power cables; and cables have under special conditions been constructed for and are operating on voltages up to 100,000.

Copper used for electrical purposes must be of the highest standard of purity, and this can only be attained by a number of processes which may be briefly outlined as follows:—The ore, containing sometimes only 3 or 4 per cent of copper, is first treated to extract part of the sulphur. It is then smelted into what is called "matte" which consists of about 50 per cent copper and a large percentage of iron sulphur and other impurities, besides small quantities of gold and silver. The matte is then treated in a converter, which increases the purity to over 97 per cent of copper, including the gold and silver. The copper is taken from the converter in the form of slabs, and these are then further treated in a furnace and again run off into thinner slabs weighing some 500 lbs. each. These castings known as "anodes" are then refined by an electrolytic process, by which the pure copper is extracted from the anodes and deposited on thin plates of pure copper. In this process, the remaining impurities and the precious metals settle to the bottom of the tank. The plates having built up to a thickness of about ½ inch are then melted down and cast into what are known as "wire bars", which are generally about 4 inches square and vary in length according to the weight desired, the most usual weight being about 250 pounds. The wire bars are delivered to the rolling mill, which rolls the hot bars into rod. The rod may be either round or flat in section, and is finished to different sizes according to the size of wire to be drawn. Ordinary standard sizes of wire are drawn from rods ⅝ inch to ¼ inch in diameter.

The wire manufacturer in turn takes the copper at his mill in the form of "rod" in coils generally 200 to 250 pounds in weight and draws the rod in cold form through dies of chilled iron or diamonds. These dies require to be very accurately drilled, and are constantly replaced as they show signs of wear. Diamond dies are used exclusively for the smaller sizes of wire.

The process of drawing the copper through dies has the effect of hardening the copper, and it is therefore necessary to subject it to an annealing process if soft copper is required. In the most modern annealing furnaces, as used by this Company, the wire is passed through an externally heated retort, which is sealed by water at both the entrance and exit so that no air can enter the retort. The result is that the wire comes out perfectly annealed and bright and has suffered no loss in weight.

Bare wire is, as previously mentioned, made up in many forms and for many different purposes. The largest wire generally used is trolley wire, which is always hard-drawn to give it the necessary strength and wearing qualities. This is made up either round or grooved, the latter form enabling the wire to be gripped by the ears or hangers and still leave a smooth running surface on the under side of the wire.

This Company has recently introduced an alloy of cadmium and copper, which on prolonged tests as trolley wire in actual operation appears to have three to four

times the life of copper with only a slight decrease in the electrical properties of the wire. Other alloys previously used have an electrical resistance of more than double that of copper, causing a consequent diminution of the permissible current they can carry.

Bare wire is also used for telegraph, telephone and power lines of high voltage. Low-pressure power lines are generally constructed with weatherproof wire or cable, the weatherproofing consisting of one, two or three cotton braids impregnated with a pitch compound. This affords a certain amount of protection to the men working on the lines, and is also a protection against the accidental contact of other lines.

As an insulating medium especially for the smaller sizes of wire and cable, rubber is the most extensively used. Practically all the interior wiring of buildings is done with rubber-insulated wires, the rubber being protected by weatherproof braid, or in some cases with a lead sheath. Flexible cords are all rubber insulated, and power cables are to a limited extent insulated with the same material, though these are principally for low voltages; and they have been superseded to a great extent by other insulations. The rubber is extruded through a die around the wire by machines in which the rubber compound is heated to a plastic consistency; and the reels of rubber-covered wire are treated of vulcanizing ovens before the braid or other external covering is applied. The majority of wires are tinned before the rubber is applied, to prevent the tarnishing action of the sulphur in the rubber. Flexible cords are covered with a layer of cotton next to the copper, in place of tinning.

Flexible cords are made up in a large variety of forms. The most widely used is the twin lamp cord in which two separately insulated conductors are twisted together with no further protection; or the same conductors may be covered overall with a plain, waxed or weatherproofed braid. The two conductors may also be laid together parallel without twisting and covered with any variety of outer protection. They may be braided with asbestos as in the case of heater cords for portable heating appliances such as toasters, irons and radiators. They may be braided with silk for decorative effect, or with a hard cord braid for rough usage. They may consist of any number of separate conductors, and the conductors may be of many different sizes. When it is considered that, in addition to all these standard varieties, many special designs are asked for, it is readily seen that the competent manufacturer must be prepared to handle a wide variety of output.

The manufacture of "magnet wires" is quite an important part of the industry. These are mainly used for the winding of all electromagnetic coils for instruments, generators, motors, etc., and consequently the range of sizes and varieties is very considerable. Wires were formerly insulated most generally with one or more winds of silk or cotton, but the use of enamelled wire especially for the smaller sizes is now becoming more general, and the Company installed last year a very modern equipment for this process. The enamel is baked on the wire, and forms a tough but elastic covering, impervious to moisture and possessing high insulating qualities. This wire is used either plain enamelled or with an additional covering of silk or cotton. Magnet wires are manufactured in round, square or flat sections, cables in round or square sections.

The manufacture of "power cables" is in some respects the most important branch of the industry to-day in that it calls for the greatest proficiency in design, the highest skill in fabrication, and the most careful selection of materials. The tendency is always and ever towards higher and higher voltages, and cables operating at 30,000 volts have long since passed the stage of novelty. At the same time, the designers are tending to reduce the thickness of insulations, and thus reduce costs and diameters.

The use of paper as an insulating medium for power cables is practically standard practice in all countries, and the ingenuity of chemists and engineers has failed to produce any material during the past 30 years which has any real claim to supersede paper. The paper is applied to the copper conductor in the form of narrow strips wound helically in a succes-

sion of layers to the required thickness. The papered conductor is then dried in vacuum ovens, and afterwards impregnated with an insulating compound, consisting generally of a petroleum or resin oil base mixed with certain other ingredients. The insulated cable is then enclosed in a lead sheath, which is extruded on to the cable in a plastic state by hydraulic pressure.

To ensure the absolute continuity of the sheath and its freedom from minute holes or other defects, the cable is immersed in water for 24 hours, after which the required electrical tests are carried out. The function of the lead sheath is to act partly as a mechanical protection to the insulation, but principally to provide a waterproof envelope, as one of the main disadvantages in the use of paper as an insulator is the fact that it is hygroscopic, or moisture-absorbing, and must therefore never be exposed to a damp atmosphere. For this protection, lead is the most suitable material, being easily applied and extremely ductile, enabling the cable to be readily bent without cracking or buckling the sheath. It is in this form that power cables are most generally used, and the majority of those which are drawn into conduits beneath the streets are of this type.

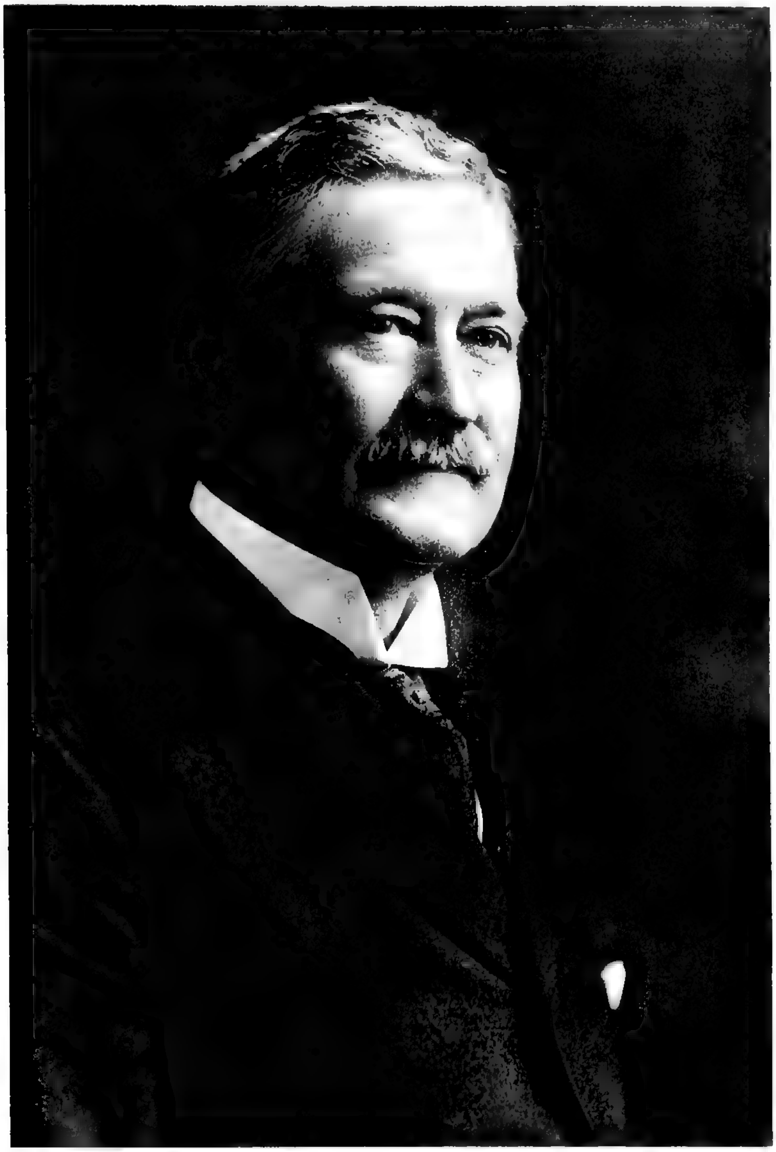
Many cables, however, have an additional protection in the form of steel wire or steel tape armor. In cases where the cable is liable to be subjected to mechanical strain, as in the case of a submarine cable, steel wire is used, and is applied in the following manner: The lead-covered cable is first served with a layer of compounded jute, and on this are wound helically two layers of steel wire of a size determined by the diameter of the cable and of such number as will completely cover the cable. The two layers are wound on in reverse directions, and over the wire is served another layer of compounded jute. In cases where mechanical protection only is required, and where there is no probability of excessive strain, steel tape is used in the same manner as the wire, except that the two layers are wound in the same direction and so as to "break joint"; that is to say, the outer tape covers the space between the turns of the inner layer, this space being necessary to enable the cable to be bent readily.

This type of armored cable has attained great popularity by reason of the increasing use of underground cable for street-lighting systems, etc., where a minimum of cost is essential. The armored cable is laid directly in a shallow trench in the earth, and constitutes the cheapest method of laying a cable underground; and, while the life of such a cable must of course vary under different circumstances, it would appear that with average conditions 25 years is a conservative estimate.

Another form of insulation which is sometimes used as an alternative to both rubber and paper is varnished cambric. This is simply cambric cloth treated with an insulating varnish, and it is applied in strips similarly to paper. While this is rather less hygroscopic than paper, it requires a lead sheath, unless used in interior dry situations, when it is weatherproof or flameproof braided in the same manner as rubber.

Telephone cables have been in use to a greater extent than power cables, for the reason that their cost is comparatively small, and that a very large number of wires can be incorporated in one cable. Cables containing 800 pairs of wires are in common use, and supposing there are only a few such cables running under the surface of a street, the running of a similar number of bare wires on poles along such a street would be quite impossible, physically, while the maintenance would be costly beyond comparison.

In the fabrication of these cables, each individual wire is first separately insulated with a loose wrapping of dry paper. Two such wires, forming a pair are then twisted together, the color of the paper on one wire being distinctive from the other. A certain number of these pairs are then laid up together helically, and over them successive layers of pairs are laid on, the twist of each layer being the reverse of the layer below, and the pairs in each layer being colored distinctively from those in the layer below. This color scheme is planned to facilitate the splicing together of two lengths of cable, maintaining the relation of the pairs in each layer throughout. When the cable is



HARRY WRAY WELLER

stranded to the required number of pairs, a paper wrapping is wound over all and the lead sheath applied. These cables are also supplied with armor protection similar to that of the power cables.

Many other forms of wires and cables are manufactured at this plant including numerous special designs which cannot even be referred to in this article; but the above general description may convey an impression of the standard forms in which copper wire is utilized.

By 1920 business had developed to such an extent that it was found necessary to make plans for further development, and, as the property owned by the Company at Mile End was of insufficient area to permit of the proposed extensions being carried out, careful investigation was made of a large number of sites in the provinces of Quebec and Ontario. A suitable site comprising 132 acres was finally selected at historic Brockville, Ont., on which the Company will immediately construct a copper rod rolling mill which will actually be the first in operation in Canada, and which will have a capacity of 100 tons per day, provision being made for increasing this capacity as the demand develops.

It is the intention of the Company to construct ultimately on the same site a very complete wire and cable factory which will be the most modern plant of its kind on the Continent of America for the manufacture of bare and insulated copper wires and cables.

HARRY WRAY WELLER

Mr. Weller, born January 4, 1858, London, England, the son of a barrister there, was educated at Derby, and in 1873 took third class honors in the University of Cambridge local examinations, having specialized in chemistry and machine construction and design. He was first employed at Derby on the great Midland Railway System, but after 4½ years took up mining and civil engineering, for which there was large opportunity in the central coal fields of England. Having occasion to visit the U. S. A. on engineering business in 1882, he returned to the old country to follow the profession of civil engineering; but he soon felt constrained by what he had seen on his trip of investigation to cross the Atlantic again, and in 1889 did so. He was one of the early engineers of the Sprague Electric Company, whose various traction and motive power developments gave unlimited elbow room for his already large experience. A subsequent consolidation took the Sprague interests into the Edison General Electric Company with him as a special engineer and assistant manager of the Railway Department. This in turn was merged into the present General Electric Company, with which, and the Columbian Electric Railway Company, Mr. Weller was actively engaged in construction until 1894. At this juncture, utilizing in quite another field his experience in coal and coke mining and civil engineering at Chesterfield and Darlington in England, Mr. Weller became identified with American steam engineering as New England manager for the well-known Campbell & Zell Boiler Company. In a few years with a constantly growing reputation, he had made himself widely known, and in 1899 he was sent to Canada as the representative of Babcock & Wilcox, Limited, for whose very large boiler interests in the Dominion he has now been manager for over twenty years.

Even this international record would not be complete without mention of the fact that Mr. Weller was also, while in England, engineer to the Chesterfield Rural Sanitary Authority, and that the unusual studies in special civil engineering problems thus necessitated, proved very useful in the later work on this side of the Atlantic in many ways. But it was an extraordinary transition at first in America, for early trolley work was bristling with tremendous new problems, and in Mr. Weller's memory will always stand out his first efforts to "free the mules" at Atlantic City; or at West Bay City, Mich., in the hard winter of 1889-90, running over light strap rails with no snow plows and making contact through adamantine ice with steel track bristle brushes, or for a diversion fitting carbon brushes on the

generators at the power plant to save the commutators from the devastating grind of the primitive copper brushes. To swing from that to the equipment of half a continent with the latest types of water tube boilers, and do it with ease and success, was "going some."

As a "hobby" Mr. Weller has been one of the pioneers in modern photography, beginning with wet plates as early as 1876, and making gelatine dry plates before they were put on the market commercially; and again more latterly in practicing color photography by the Lumiere process. A later pursuit has been motorboating, which again has made a strong appeal to his taste for experiment.

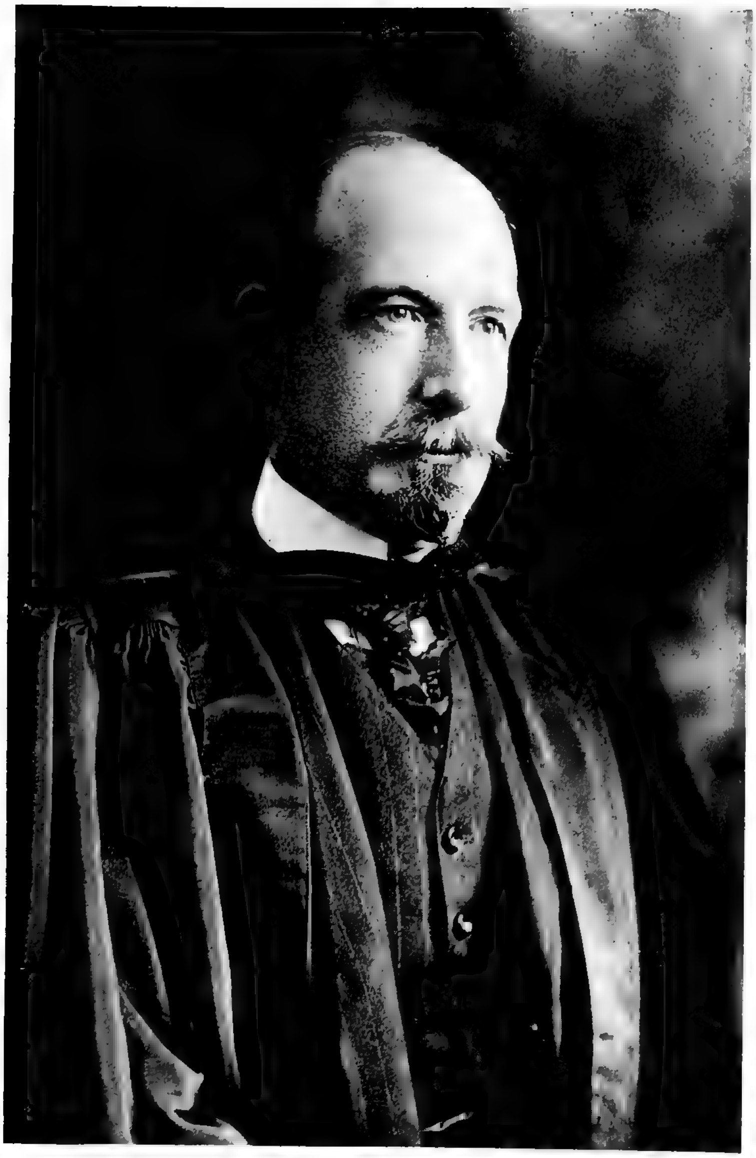
Mr. Weller has been an associate member, Institution of Civil Engineers of England since 1885; he is also a Fellow of the American Institute of Electrical Engineers, and a member of the Canadian Mining Institute. He is also a member of the Portland Power Boat Association, and Past President of the Canadian Association of British Manufacturers and Their Representatives; as well as a member of the Canadian Railway Club. In social life, he is to be found in the membership of the Constitutional Club of London, and the Engineers' Club, Old Colony Club, and Rotary Club, all of Montreal. Another indication of Mr. Weller's life interests and outlook is to be seen in his Masonic affiliations, as he is a member of the Royal Albert Lodge, the A. & A. Scottish Rite, and the Royal Order of Scotland, all of Montreal; and also of St. Paul's Royal Arch Chapter of Boston.

His offices are in Montreal and his residence is 79 Arlington Avenue, in the Westmount section of that city.

LOUIS A. HERDT

Born June 14, 1872, at the famous seaside resort Trouville, France, Dr. Herdt, has been so long a Canadian, one is apt to assume the Dominion to be his native soil. Dr. Herdt is a graduate of McGill University, B.Sc. in 1896, and a pupil of the Montreal High School, he is also an E.E. of the well-known Montefiore Electrotechnical Institute of Liège, Belgium, and a graduate of the Laboratoire Central d'Electricité, Paris. It may be added here that he became Ma.E. (Master of Engineering) of McGill in 1902, and a D.Sc. in 1910.

Having been sent to Europe in 1896 to study there the new science of electrotechnics, he joined the forces of the French Thomson-Houston Company in 1898, being very much at home owing to his Huguenot descent, and the service of his father as an officer in the Franco-German war. But after a two years' stay in France he gravitated back to Canada, became a demonstrator on the staff of the faculty of the applied sciences at McGill and by natural advances became the head of the Department of Electrical Engineering of McGill, in 1912, his actual tenure of office dating back to 1909. Deep, however, as has been his imprint on electrical education in Canada, Dr. Herdt is if anything better and wider known apart from his alma mater. He was decorated by the French Government as an Officier d'Academie in 1905, and has long been a Fellow of the Royal Society of Canada. He is president of the National Committee, Canada, of the International Electrotechnical Commission; chairman of the Electrical Commission, Montreal; and vice-chairman and consulting engineer of the Montreal Tramways Commission. He is also the honorary secretary for Canada, and a Fellow of the American Institute of Electrical Engineers. He has been consulting engineer for the City of Winnipeg hydroelectric development, and for the lighting, traction, and power transmission utilities of the city of Ottawa. The Great War found him ready to serve and he performed the duties not only of a lieutenant in the Canadian Officers' Training Corps but of Chief Inspector of the French Military Commission to Canada. Dr. Herdt is also a member of the Engineering Institute of Canada and of the Engineers' Club and the Montreal Club.



PROF. L. A. HERDT, D.SC.

It is, however, when we turn to Dr. Herdt's original contributions to learned and engineering societies that a real measure of his great services to science is found. The topics range widely and include: Waveform of alternators; surging in high tension lines; polyphase equipments of European high speed electric roads; electrolytic lightning arresters; direct current long distance transmission; armature reaction and the compounding of alternators, and the use of electricity on the Lachine Canal. The bodies addressed are equally varied including the Canadian Electrical Association, the American Institute of Electrical Engineers, the Canadian Society of Civil Engineers, and the Société Internationale des Electriciens of France.

All this again has been supplemented by a great many appearances in the technical press. Dr. Herdt furnished the *Electrical World* in 1909 with a valuable chart for the calculation of transmission lines, followed by similar work for the old *Lumière Electrique* in 1909; and articles are to be recorded also on polyphase armature reactions in the Chicago *Electrical Review;* on the electrolysis of Winnipeg water mains in the *Canadian Electrical News;* and on armature reaction and the compounding of alternators in the London *Electrician.* The work of an educator is most likely to carry through to success when the teacher has also had some of practical experience for which he is qualifying his pupils; judged by which standard as well as by the actual student graduate body, the life of Dr. Herdt as an upbuilder of the Dominion and of McGill since the early days of expansion with Dean Bovey, stands out for its conspicuous achievement.

THE NATIONAL ELECTRIC HEATING COMPANY, LTD.

The National Electric Heating Company, Limited, located at Toronto, had its origin in 1907. It was started by Mr. A. Pritzker, the present secretary, treasurer, and managing director. The first business was to manufacture electric irons, but disc stoves, toasters, air heaters and other electrical appliances for the home were added in due course as the business progressed.

In 1911 the company was incorporated, and the next year the present factory in Toronto was built and new lines were added until, today, the industry is one covering every electrical appliance for the household. It has always been the aim of the company to manufacture goods of the highest quality, and its productions are being sold by the most progressive jobbers and dealers throughout the Dominion as well as in many foreign countries. It is the intention in the near future to build a larger factory so that the growing demand may be met.

In addition to Mr. Pritzker, the other officers of the company are: Mr. Leo Frankel, president, and Mr. B. Enushevsky, vice-president.

PAUL F. SISE
President Northern Electric Co., Ltd.
Montreal, Canada

PAUL F. SISE

No man was better known in his day and generation in the telephone field than the late Charles F. Sise, who organized the Bell Telephone Company of Canada, and was successively its managing director, president and chairman of the Board—being also president of the Northern Electrical Manufacturing Company and the Imperial Wire & Cable Company, Ltd. He died in 1918. His third son, who has been active in the following up of that great pioneer career, is Paul F. Sise, who was born in Boston, Mass., on November 10, 1879, but has been closely identified all his life with electrical development in the Dominion. He was educated at Bishop's College School, Lennoxville, Que., and McGill University, graduating in 1901 with the degree of B.Sc., and being a member of Alpha Delta Phi. On leaving Montreal he followed up his special courses in mechanical and electrical engineering by becoming a student apprentice with the Westinghouse Electric & Manufacturing Company at Pittsburgh, Pa., in June, 1901. He then entered its construction department and in 1903 joined the sales force of the Canadian Westinghouse Company, where he remained until December, 1904. At that time he became secretary-treasurer of the Northern Electric & Manufacturing Company and in 1910 he became its managing director, advancing respectively as vice-president in April, 1914, and president in 1919. Meantime in 1914 the Northern Electric Company, Ltd., was organized and purchased the older Northern Company and the Imperial Wire & Cable Company, which were thus consolidated.

This is a brief record of an active connection on the part of Mr. Sise with the great growth and development of electrical enterprises in Canada since the beginning of the Twentieth century due largely to forces and reputation so brilliantly built up by the senior Sise; so that the father and son may be said to have extended their sphere of influence by working in parallel and in series.

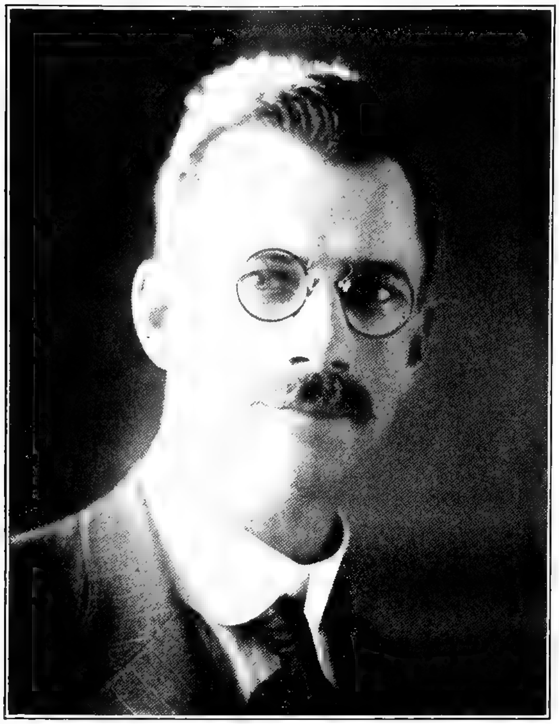
Then came the great convulsion of the World War of 1914. Mr. Sise joined the Canadian Expeditionary Force, serving in Canada and England, December, 1915–February, 1917; and then became a member of one of the British War Office Staffs in the United States, June, 1917–September, 1918. This was the terminal period for most men who saw active war service; but Mr. Sise went further and longer in military duty; and was a member of the Canadian Expeditionary Force which shared in the curious aftermath of the great struggle and held the outposts of civilization after the terrible Russian debacle, in Siberia from September, 1918, to May, 1919.

Mr. Sise is a member of the Engineering Institute of Canada, the St. James Club, Montreal, the Montreal Racket Club, the Royal Montreal Golf Club, the Alpha Delta Phi Club, New York, and the Anglo-American Fish and Game Club. His offices are those of the Northern Electric Company, Ltd., 121 Shearer Street, Montreal.

WALTER J. FRANCIS & COMPANY

(Consulting Engineers)

The firm of Walter J. Francis & Company, consulting engineers, 260 St. James Street, Montreal, Canada, consists of Mr.



WALTER J. FRANCIS

Walter J. Francis, C.E., member of the Engineering Institute of Canada, Institute of Civil Engineers of Great Britain, American Society of Civil Engineers, and the American Institute of Consulting Engineers; and of Mr. Frederick B. Brown, M. Sc., member, Engineering Institute of Canada, American Society of Mechanical Engineers. Mr. Brown is also a lecturer in Engineering Economics, McGill University, Montreal.

The firm was formed in 1910, and has done a great deal of general engineering work in an advisory and supervisory ca-

FREDERICK B. BROWN

pacity. Among other things it has been identified with the development of many steam, hydraulic and electric power systems as well as with the economics of operation of these and similar industries. The services of both members of the firm are often called upon in connection with arbitrations, valuations and court work of all kinds. The modern public utility field opens up a great variety of such professional opportunities.

CHAPTER XX

DISTINGUISHED ENGINEERS, MANUFACTURERS, AND LEADERS IN THE ELECTRIC FIELD

FRED ALLISON

Mr. Fred Allison, superintendent of power and chief electrical engineer of all power equipment of the Ford Motor organizations throughout the world, occupies a unique position in the electrical field.

Mr. Allison was born at Cadillac, Mich., in 1881, and during the forty years of his life has crowded in a world of experience. He must have had a natural aptitude for electrical affairs. He is not a graduate of any of our great technical schools, yet his knowledge of electricity has obtained for him a Fellowship in the American Institute of Electrical Engineers and a position at the head of one of the greatest power plants in the world. He was, on the other hand, the first student to enroll in the electrical engineering course of the International Correspondence Schools at Scranton, Pa.—taking advantage of the best thing within his means at that time to strengthen his knowledge of electrical affairs. Mr. Allison went to Detroit from Cadillac in his youth and attended the Detroit schools. His first employment was with the Michigan Auxiliary Fire Alarm Company, where he spent two years in their shops on apparatus design, thus gaining a practical knowledge of the operation and construction of storage batteries which enabled him to find employment with the Detroit Edison Company along that particular line. This position led to another with the Electric Storage Battery Company of Philadelphia where he was engaged in research work in what were the early experimental stages of the "Exide" type of battery, then being perfected for use in self-propelled vehicles. Mr. Allison was on the road for and attended the installation of most of the Electric Storage Battery Company's initial work. Following this work, Mr. Allison became connected with the Commonwealth Edison Company of Chicago. His job was to design controlling apparatus for the special vehicles which the company was about to use in its service. Follow-

ing the completion of this work and associated with Mr. Ernest Lunn, now of the Pullman Car Company, and with Mr. Willard G. Carlton, at present superintendent of the electrical division of the New York Central Railroad, he promoted and organized what is believed to be the first and at that time the largest vehicle garage in the United States, for housing vehicles of the Commonwealth Edison Company, and known as the Automobile Equipment & Maintenance Company of Chicago, which company was later taken over and is still in possession of the Commonwealth Edison Company and known as the Walker Company.

From the time of Henry Ford's first experiments with the self-propelled vehicle, Mr. Allison has been his advisor and associate along the electrical side of the various departments of motor cars. Mr. Allison has been directly connected under contract with the Ford plant for over 17 years and this covers some space in the young life of the automobile industry. The starting apparatus used in all Ford cars throughout the world is known as the "F.A. Starter." The "F.A." stands for Fred Allison. It was invented by him for this specific purpose, and we believe is used on other motor cars as well.

During Mr. Allison's connection with the Ford Company he has designed and installed power plants aggregating a total of 100,000 kw. Some of this equipment is in the main plant at Detroit, which is said to have the largest direct installation plant in the world. The Ford Power Company furnishes the factory with electrical power, light, hot and cold water, steam for the steam hammers, gas for heat-treating Ford parts, compressed air for special operations, heat in winter, cool washed air in summer and with sufficient refrigeration to cool the drinking water and the oil used in heat-treating. It is said the equipment is sufficient to furnish a modern city of one-half million people with water, gas, and electricity, ice, and heat, and heat enough to supply the entire business district and all the public buildings. This plant is strictly direct current having a rating of 65,000 kw. total load at 250 volts. The plant extends for 500 feet along Woodward Avenue and has a width of 200 feet and the coal storage bunkers have a capacity of 2,000 tons. This brief description of such a modern and enormous plant is wholly inadequate to a comprehensive understanding of the features which make it range the first in the world.

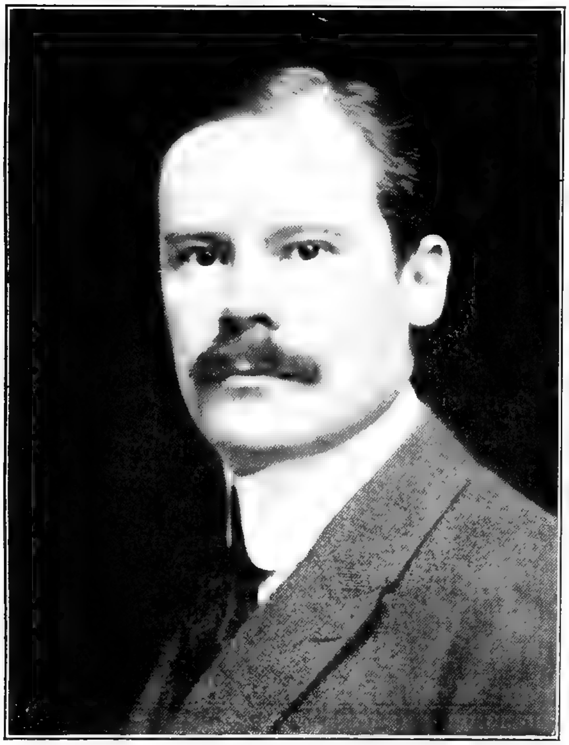
Mr. Allison has contributed considerably to electrical magazines with articles covering his experience, which is of value to the fraternity. The *Electrical World* in a recent issue contains the following: "Mr. Allison has designed many new features of plant operation, besides originating or coöperating with others in the organization of numerous devices. Among those are the light-weight electrical vehicle which Alexander Churchward and he were largely instrumental in producing, electrical welding and tempering devices, a special direct-current motor design, combination 20 h.p. to 40 h.p. motor-operated starters now being produced by the Westinghouse Company, numerous automatic control devices, electric furnaces of high temperature, and also graphitizing development, electric cleansing or producer gas by ionization, many electrolytic processes in steel tempering and many safety devices. He was concerned also with the advancement of magneto and ignition design."

Mr. Allison makes his home in the city of Detroit and his headquarters are in the Ford Motor Company in Highland Park, a suburb of that city.

FRED ALLISON

ERNST F. W. ALEXANDERSON

Sweden has always been liberal in her contributions to the arts and sciences, and her celebrities are to be found on the honor roll of every branch of engineering. The work of many of these distinguished men has been done in the United States, worthy to be associated with John Ericsson of immortal memory; and still adding



ERNST F. W. ALEXANDERSON

to a long list of notable achievements. In this respect electrical engineers may be forgiven if they point to one of their fellows, Ernst Fredrik Werner Alexanderson, born at Upsala, but for twenty years domiciled in America.

As an inventor in the electrical field, Alexanderson attained a place of distinction and international reputation at a quite early age. His unusual abilities have been applied to such diverse fields as the electrification of railroads, the electrical propulsion of ships, and communication by wireless on the grand scale. This is attested by at least 100 U. S. patents and scores of foreign patents and by numerous publications. It will suffice to note the fact that the first U. S. electrical battleship, the *New Mexico,* has an Alexanderson equipment; that the Government and the Marconi Company use his inventions in the field of wireless telegraphy and telephony; and yet that an equally deep imprint has been made by him on trolley operation and in the design and construction of electric locomotives. His paper of November 10th, 1920, before the Institute of Radio Engineers and the New York Electrical Society describing the great new central stations for radio communication, marks the furthest reach in the vital department dealt with, as exemplified in the great Alexanderson plants at New Brunswick, N. J., Marion, Mass., and Huntington, L. I.

This modest engineer who talks habitually in terms of world speech, comes of an old Swedish ennobled family, long prominent in legal and administrative affairs, and was born January 25, 1878, in the atmosphere of old world culture, son of Prof. A. M. Alexanderson. He graduated from the high school of Lund, 1896, and then studied successively at the University of Lund, the Royal Institute of Technology at Stockholm, and then did post graduate work at the Royal Technical Institute of Berlin. By 1901 he was ripe and ready for transferring his energies to the United States, where he at once secured employment as electrical draftsman with the C. & C. Electric Company. A year later he joined the forces of the General Electric Company at Schenectady, N. Y., his extraordinary genius and energy being already recognized. He was a member of the General Electric Engineering Department in 1904, and while connected with the specific work of railway engineering developed the well-known Alexanderson single phase motor, which soon passed into

general adoption, and was described before the American Institute of Electrical Engineers in January, 1908. Then came a long series of innovations and improvements, notably a phase converter, high tension direct current motors, a new method of motor ventilation and a system of regenerative braking reduced to commercial practice in the famous locomotives of the Chicago, Milwaukee and St. Paul Railroad. Supplementing these again are the high tension variable voltage ratio, rotary converter in use by the New York Edison Company, and the methods of operating induction motors at variable speed as illustrated in electrical battleship practice. A consulting engineer of the General Electric Company until 1919, he was also made in November of that year, due to his brilliant radio work, chief engineer of the Radio Corporation of America, the new company combining the radio interests of the General Electric Company and the Marconi Wireless Telegraph Company of America. His high frequency generators for wireless systems, his "multiple tuned antenna," his "barrage method of radio reception" and other inventions, are typical of the progressive work of this young engineer and of the "greater that lies before," more than justifying his Medal of Honor from the Institute of Radio Engineers.

Mr. Alexanderson is a member of several technical bodies to which he has made various and valuable contributions, but in which he sedulously avoids official rank and active participation.

LOUIS ALLIS

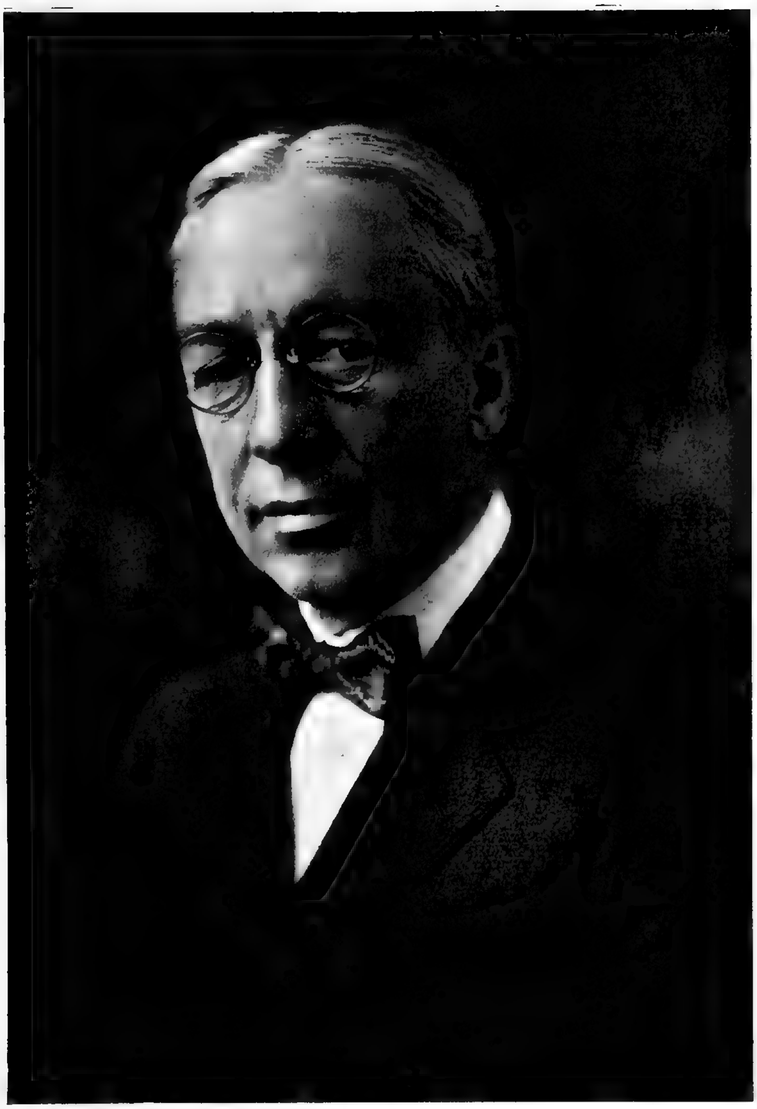
Louis Allis is of English descent and there are many references to the Allis family in the old Doomsday Book of England; the Allis family in London being a large one until the great plague of 1665, at which time it was nearly exterminated.

Members of this family early showed organizing and engineering tendencies. The first American ancestor, William Allis, having come to the United States with the Winthrop fleet in 1630, landed at Charlestown Harbor, and surveyed and laid out Mount Wollaston (afterward Braintree), a small town which was afterward incorporated to form the city of Boston.

Edward P. Allis, father of Louis Allis, was born May 12, 1824, at Cazenovia, New York, and after leaving Union College at Schenectady, went West in 1846, locating in Milwaukee. In 1861, with a Mr. McGregor and a Mr. C. D. Nash, he purchased the iron foundry of Decker & Seville and formed the Reliance Iron Works, which was the nucleus from which was later to grow the Edw. P. Allis Co.; subsequently the Allis-Chalmers Co. He became manager of the Reliance Iron Works, and within two years of its inception had acquired the interests of the other two men, and from then until his death, April 2, 1889, was sole proprietor of The Edward P. Allis Co.

Louis Allis was born at Milwaukee, December 30, 1866, and at a very early age showed great interest in manufacturing, a considerable part of his childhood having been spent in his father's shops, where he was a great favorite with the men. He was educated at Markham Academy, Milwaukee, and at the Pennsylvania Military College, receiving a degree of Civil Engineer in June, 1888.

On graduating from college he entered the employ of the Edward P. Allis Co. as storeroom clerk in September of that year. About 1889 he was responsible for the installation of first aid and hospital facilities at The Edward P. Allis Co., and from this nucleus in connection with the then established Allis Mutual Aid Society, developed one of the first complete welfare organizations of any consequence in this country. His advance to receiving clerk and purchasing agent was rapid, and although he nominally retained that title, he expanded his activities until he was virtually general manager. He left the employ of The Edward P. Allis Co., due to illness, in July, 1901. From then until March, 1906,



LOUIS ALLIS

Mr. Allis was interested in the control of 80,000 acres of timberland and various mining properties.

In 1903 Mr. Allis was elected president of The Mechanical Appliance Co., his manufacturing and executive talent making it natural that he should get back into the manufacturing business. There was another and more important motive which actuated Mr. Allis in assuming the presidency, and that was a broad and sympathetic comprehension of and a desire to aid in the improvement of conditions surrounding employees. Those who have been closely associated with him have good reason to remember numerous instances in which, through advice and in a much more substantial manner, he has enabled them to improve their condition and character.

Under his guidance The Mechanical Appliance Company has grown from a comparatively small and insignificant beginning to a position of very considerable importance in the electrical industry. His policy has been one of consistent integrity as regards the quality of apparatus, and under his encouragement a very considerable amount of specialized development has taken place, which has resulted in placing The Mechanical Appliance Company in a unique position among the American electrical manufacturers. Under his guidance the condition of the company has shown a steady improvement to the point that today it has become a real institution.

The Board of Directors felt that the Mechanical Appliance Company name was hardly indicative of the ideals and the activities of the organization. As a result Mr. Allis was approached, and, as an expression of his confidence in the institution and in the electrical industry an agreement was reached whereby the name should be changed to the Louis Allis Co. This change was made May 5, 1922.

Mr. Allis is or has been a director and president of the Cazenovia Land Company, Battery Light & Power Company, The Edward P. Allis Co., Elizabeth Mining Co., and The Louis Allis Co., formerly named The Mechanical Appliance Co., director, vice-president and treasurer of the Milwaukee Boiler Co.; director and general manager of the Gogebic Lumber Co.; director and treasurer of the Geneva Land & Mining Co.; director and vice-president of the Central Improvement Co.; general manager of the Horseshoe Mining Co., all of Milwaukee; and director of the National Wrapping Machine Co., now of Springfield, Mass.

Mr. Allis is a member of the Milwaukee Club, Milwaukee Country Club, University Club, Blue Mound Country Club, Milwaukee Athletic Club, Town Club of Milwaukee, Rotary Club of Milwaukee, Milwaukee Association of Commerce, and the Electrical Association of Milwaukee, all of Milwaukee; the Electric Power Club, Electrical Manufacturers' Club; the Travelers' Club of Paris, France; and the Société de la Boulie, Golf de Paris, near Versailles.

Mr. Allis is particularly interested in the American Constitutional League of Wisconsin and in the welfare of his city's hospitals. His recreation is principally in the game of golf.

HAROLD ALMERT

Born in Chicago, June 2, 1876, Mr. Harold Almert, has the distinction while still a young man of having already reorganized and rehabilitated over half-a-billion dollars' worth of electric light, street railway, gas and telephone properties. Beginning such a professional career with eight years of technical training, he has managed to round out his mental discipline with three years of legal studies and two devoted to accounting; and all to some purpose, for no one can deny that a modern utility needs all the natural and acquired acumen that can be brought to

bear on it. The old Western Light & Power Company gave him the first opportunity to begin, literally from the ground up, for he set poles before going

HAROLD ALMERT

through the full routine of power plant, shops and office. He next became superintendent of its water and light plant for the Lincoln Park Commission, Chicago, pursuing studies also at night, and then taking up experimental engineering with the Chicago Telephone Company. From that he passed with easy transition to public utility construction, with such marked results that he is to be found when only 26 years of age president of the Northwestern Electrical Association. It was then that the next vital step was taken, for observing the poor load factor of most public utility systems he set himself to broaden their service and so improve it as to make them not only self-supporting and profitable but on the basis of enjoying the approval of the community in which they operated. During this interesting period, Mr. Almert was a director or executive officer of properties with investments ranging from $500,000 up to $18,000,000, leaving one utility to go to another as soon as the necessary work of construction or rehabilitation had been done. For the past ten years most of his time and that of his organization has been given up to questions of valuation, rates, regulation, etc.

At the outbreak of the World War, Mr. Almert had a staff of ninety engineers, accountants, statisticians, etc., but under the urgent appeal of governmental authorities he gave up private practice to devote himself to work that was part of "winning the war" and he gave excellent service as Director of Conservation for the U. S. Fuel Administration for Illinois. During this period he developed a process adopted by the Fuel Administration for saving coal through the use of an attachment enabling any base-burning stove using hard coal thereafter to consume soft coal, without smoke, and reducing the cost of fuel by 50 per cent. The Administration distributed millions of copies of pamphlets on the subject. Mr. Almert also served as Deputy Commisioner of Health of Chicago, as consultant on the elimination of smoke; but since March, 1919, he has resumed active practice as a consulting engineer and technical counsel. His field of service in this respect has covered almost every State in the Union.

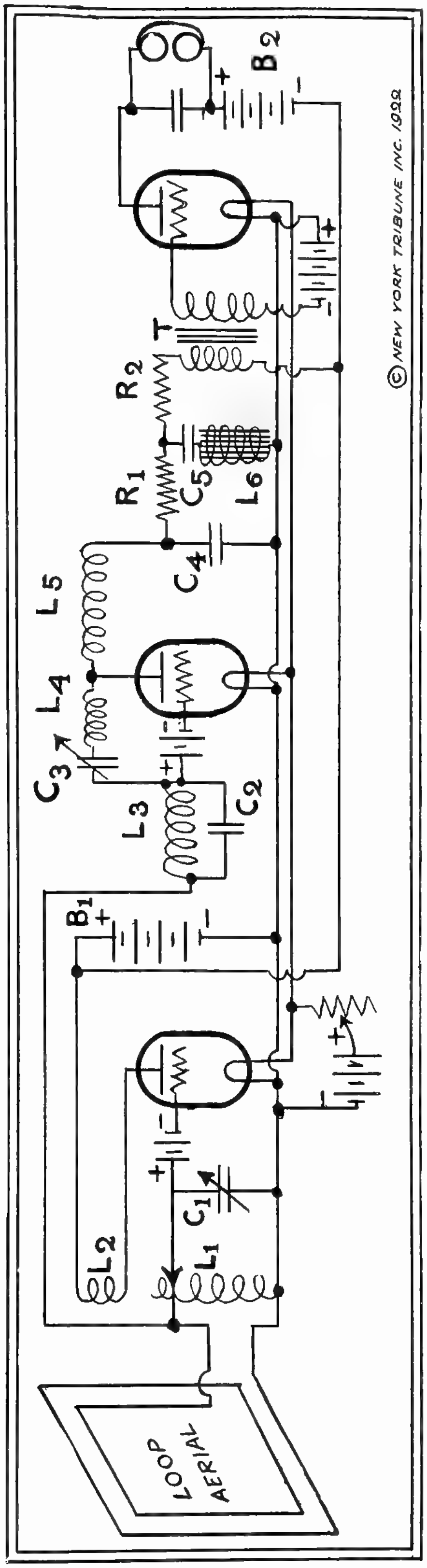
Mr. Almert is a past-president of the Chicago Electric Club, and the electrical section of the Western Society of Engineers. He is in addition a member of the three great engineering bodies, the A. S. C. E., the A. I. E. E., and the A. S. M. E., as well as of the two great utility bodies, the National Electric Light Association and the American Gas Institute; and of the Western Society of Engineers; the Society of Automotive Engineers; the American Electric Railway Association; the American Association of Engineers; and the National District Heating Association. He is also a member of the Engineers' Club of New York; the Chicago Electric Club; the South Shore Country Club; Midday Club, Chicago; and the Old Colony Club. It is almost needless to add that his business headquarters are in Chicago, in the Rookery Building, but it will be inferred from the above narrative that the calls are incessant for his presence elsewhere.

EDWIN H. ARMSTRONG

Technical decisions in the national courts are rarely received by the public with any degree of concern although they may deal with large questions of scientific application and involve the disposal of highly important financial and manufacturing interests. Very often such cases fall into the category of Jarndyce suits in Chancery, and are settled when the original proponents and antagonists have passed from the active stage of life. It is quite different in the "radio" field, whose wonderful instantaneity and expansion tells of an art that has suddenly sprung fully equipped from the brain of inventive youth, but whose vital legal verdicts are coming swift and fast to settle the legitimate claims and merits of men who by their skill in setting the ether jazzing have virtually in the last ten or fifteen years endowed the world with new powers of communication which were utterly unknown when Morse first ticked out his immortal message, "What hath God wrought!" and were only foreseen dimly by such prophetic leaders as Henry and Faraday.

One of the swiftest decisions has just been handed down to a man who stands out prominently as one of the foremost radio inventors at one of the most epochal moments in the advance of the new art. Last March Major E. H. Armstrong, of the U. S. Signal Corps during the Great War, received from the U. S. Circuit Courts of Appeals of New York City a strong verdict sustaining the lower court in its decision favorable to his patent on radio circuits. The great physicist Pupin, of Columbia University, says: "This decision refers to one of the most important inventions, if not the most important in the wireless art. It is the invention of employing in connection with an audion a coupling which enables a local battery to contribute its energy to the amplification of a signal received in a wireless station. The contribution obtained in this manner from the local battery or the local source of energy may be made as large as we please within certain definite limits. Armstrong was the first to employ this coupling, or, as it is called, the "Armstrong feedback circuit." The invention enabled him to make another most important step in wireless telegraphy, and that is the construction of a vacuum tube oscillator. . . . It is a generator of electrical oscillations, maintaining its pitch with a degree of accuracy never before obtained by any apparatus constructed by man."

Praise from Pupin is praise indeed, when it comes to wireless achievement, but the above may be fitly supplemented from the eulogistic technical comments made when Major Armstrong read a paper last June before the Institute of Radio Engineers. One authoritative statement remarked: "At one stroke, the new system opens up the unexplored territory in wave-lengths below 100 meters, which involve electrical currents alternating at the stupendous rate of more than 3,000,000 cycles a second. It sweeps away from radio broadcasting entertainment all need for outside wires or aerials completely." The report continues in language that must be quoted here: "It removes the present bugbear of radio by completely rejecting all interference from wireless telegraph signals caused by sparks, and it also wipes out more than fifty per cent of the interference caused by static. An idea of the remarkable character of the new apparatus may be gathered from the fact that it amplifies speech and music 100,000 times greater than does the next most sensitive apparatus known—the regenerative receiver, with two stages of amplification, which was also the product of Armstrong's genius." The inventor himself calls this latest development "the super-regenerative receiver," but it is all so super, that the biographer may be for-



COMPLETE DIAGRAM OF CONNECTIONS FOR ARMSTRONG'S SUPER-REGENERATIVE RECEIVER

Three-foot loop aerial, consisting of ten turns of No. 20 B. and S. gauge silk covered magnet wire, each turn spaced half an inch from the first turn. L1, primary of standard short wave vario-coupler with wave length range of 150 to 600 meters. L2, secondary of vario-coupler with twice the normal number of turns. C1, variable condenser .001 mfd. L3, duo-lateral coil, with 1,250 turns; L4, duo-lateral coil, with 400 turns. C2, fixed condenser .0025 mfd. C3, variable condenser .001 mfd. L5, duo-lateral coil, 1,500 turns. C4, fixed condenser .005 mfd. R1 and R2, non-inductive resistance, each of 12,000 ohms resistance. C5, variable condenser .001 mfd. L6, iron core-choke coil, 100 millihenries inductance. T, ordinary audio-frequency transformer. B-1, 90-volt B battery. B2, 110-volt B battery. The C batteries shown on the grids of the three tubes have the following values: First two tubes, four volts each, negative side to the grid. These two batteries can consist of two flashlight cells joined in series. On the third tube 22½ volts. This can be a regulation 22½-volt B battery unit.

given if he in turn is tempted to apply the word "super" not only to what he has done but to the modest man himself, still so young, yet with achievement already fairly comparable with that of Edison and Marconi.

Edwin H. Armstrong was born in New York City, Dec. 18, 1890, and is therefore barely 32 years of age. He was graduated some 22 years later from Columbia University as an electrical engineer. He then enjoyed the stimulating association and leadership of Dr. Pupin, but it is a matter of fact and record that when only a boy of 15 he became interested in "radio" and erected a wireless station at his home. He obtained his first vacuum tube detector, a so-called Fleming valve in 1908, followed up in 1910-11 by a De Forest audion or three-element vacuum tube detector. Thereafter he thought and dreamed and read vacuum tubes, and as early as 1912, he actually visualized and forecast his regenerative circuit for the amplification of radio signals. To quote Judge Mayer's opinion of May 17, 1921, "His achievement was not the result of an accident, but the consummation of a thoughtful and imaginative mind." He went to his father for help in getting a patent, but his father could hardly be blamed for unwillingness to back up an invention avowedly dealing with light and airy nothings. Young Armstrong then explained vaguely what he was after to Mr. Thomas Ewing, former U. S. Commissioner of Patents and a near neighbor in Yonkers, N. Y. Commissioner Ewing, ever ready to help struggling genius, let Armstrong string one end of the antennæ in his backyard. This invention of the regenerative circuit perfected in the Marcellus Hartley Research Laboratory, was thus characterized by Judge Manton in the Court of Appeals: "We think this excellent contribution to the wireless art should be accorded the full scope which the Court below gave it in the decree. We think the decree is not too broad, but properly describes what the inventor conceived and for which protection must be granted him."

This is due and rapid course was followed by his vacuum tube oscillator, the self-heterodyne receiver, the super hetero-

EDWIN H. ARMSTRONG

dyne method of amplification, the super regenerative circuit; and, in conjunction with Prof. Pupin, selective negative resistance devices for the reduction of interference. Moreover, in the "Electrical World" in December, 1914, he published the first correct explanation ever given of the action of the audion as detector and amplifier. He also engaged later in the erection of the station I B C G of Greenwich, Conn., which in December, 1921, established the amateur record of transmitting the first non-professional radio message ever sent across the Atlantic, the receiving station being at Ardrossan, Scotland. The feat was one that greatly stimulated public interest in radio, and marked, indeed, the beginning of the new era, also, in which broadcasting is so notable an element and is playing such a leading part. While he has become so distinguished a radio engineer and "professional" himself, Major Armstrong remains greatly interested in amateur radio and in promoting the electro-technical education of the amateur.

Of course, as indeed his title and rank testify, Major Armstrong did his bit in the Great War. He served 22 months in the American Expeditionary Force as Captain and then Major, in the Signal Corps in charge of technical radio work, where his expert knowledge of the subject made his services immensely valuable to his own country as well as to the French military authorities, as attested by the fact that he received the much-coveted decoration of Chevalier of the Legion of Honor.

It would indeed be difficult to see or set limits to a career like that outlined above. Even now wonderful possibilities are in sight for Major Armstrong's most recent work. Dr. Pupin stated not long ago that one of the leading electrical corporations was engaged in experimentation with powerful Armstrong vacuum tube oscillators with an output of upwards of fifty kilowatts; and that such tubes have practically unlimited possibilities in communication; while their application in other electrical industries will in the near future result in some revolutionary changes of vast importance. It is not to be wondered at that the name of Armstrong in connection with the marvellous advances in radio has been so prominent and so enthusiastically received not only by the technicians but by the public, swift to realize the significance of much of it, because of its broad social and international aspects.

Major Armstrong is a man of large sympathies, especially in relation to young men in whose ranks he still stands. At Columbia he was a member of Theta Xi and of Sigma Xi. He is also a member of the Institute of Radio Engineers and of the Radio Club of America, as well as of the Hudson River Country Club. His general acceptance and popularity in his own chosen field of work may be inferred from the simple fact that on the occasion of the recent conferring of two gold medals on Senator Marconi in New York, during his visit this year, 1922, to the United States, Major Armstrong was selected as a leading radio representative and was one of the few chosen to speak and extend greetings to the illustrious Italian.

Major Armstrong's headquarters are at the Marcellus Hartley Research Laboratory, Columbia University, New York City, and he resides at 1032 Warburton Ave., Yonkers, N. Y.

BION J. ARNOLD

Of Bion J. Arnold, it was written by one of the editors of "The Story of Electricity," just about ten years ago, in the *Scientific American,* as follows: "Public service commissions feed out of his hand. Public service corporations rise up and call him blessed. A court or a master in chancery is perfectly willing to accept his report on the value of a big property; and the banker is ready to accept his verdict in making large investments. There is something fundamentally fair and equitable in his mental make-up that leads to a profound confidence in his trustworthiness and ability, explaining all this. Had he been a lawyer, Arnold would have been an ornament to the United States Supreme Bench, but he would never have filed a minority opinion. He has a profound conviction as to his own inerrancy; but believes that eleven men are more likely to be right than one. Moreover Arnold would probably never have been satisfied with the income of a judge." Another decade of achievement and public service has but emphasized the justice of these generalizations and warrants their repetition here.

Bion Joseph Arnold, engineer, inventor, leader in his fields of work was born at Cazenovia, Michigan, August 14, 1861, son of Joseph Arnold, a lawyer, and of Geraldine (Reynolds), a teacher. To the tastes of his parents was certainly due the fact that this eminent engineer, who has little that is notably classical or agrarian about him, was named after a famous Greek bucolic poet. The family, dating back to an old Rhode Island ancestry, brought up soon after Bion's birth, in Nebraska, where his father was a pioneer founder of the new blacksoil commonwealth and a useful member of the Territorial legislature. The boy soon manifested remarkable mechanical ability, "throwing back" to some remote New England ancestor, and though he did not "care a continental" about farming he did make models of novel and weird farm implements before he was eight years old. He built under adverse conditions a small steam engine at 10, a bigger one at 12, a full-sized bicycle at 15, and a working miniature steam locomotive one-sixteenth actual dimensions, but complete in every detail, at 18. Then he was ripe for college, becoming a student at the nascent State University of Nebraska at Lincoln in 1879-80, and spending his summers in travel for engine companies or as an instrument man with surveying parties. He graduated as B.S. at Hillsdale College, Mich., in 1884, as M.S. in 1887 and M.Ph. in 1889. But he was not satisfied until he had taken a post-graduate course in electrical engineering at Cornell University, 1888-9. To all these evidential "tabs" of his training in higher education, may be added his honorary diploma for achievement in invention and engineering from Hillsdale in 1893; his honorary degree of D.Sc. from Armour Institute of Technology in 1907; and his honorary degree of Doctor of Engineering from the University of Nebraska in 1911.

In the school of hard knocks, Arnold won his grades as a traveling traction engine expert in 1884-6; a draughtsman, engineering department of the now Allis-Chalmers Company; chief designer Iowa Iron Works Co., Dubuque, Ia., 1887; mechanical engineer, Chicago Great Western Railway, 1888-9; consulting engineer, Chicago office, General Electric Company, 1889-1903; independent consulting engineer from 1893 up to the time of entering the service of the United States in December, 1917, and thereafter when the Great War ceased.

For several years Arnold did miscellaneous odd jobs of construction, largely in the electrical field, and then he designed

BION J. ARNOLD

and built the famous Intramural Elevated Electric Railroad at the Chicago World's Fair, 1893, the first real commercial third rail system in America. He did some remarkably interesting work in electric traction with storage batteries, and then developed much of the modern electric railway practice, including the pioneer A.C. and D.C. road between Chicago and Milwaukee in 1897-8, and the single phase line at Lansing, Mich., in 1900-4. In 1907 he converted the St. Clair tunnel of the Grand Trunk Railway, between Port Huron, Mich., and Sarnia, Ont., from steam to single phase traction. From 1907 to 1909 Arnold acted as consulting engineer for the Chicago Board of Trade, the Chicago, Burlington & Quincy, Grand Trunk, New York Central, and Erie railroads. He was the first independent engineer called to advise on the feasibility of electrifying the Grand Central Terminal in New York City in 1901, and was a member, 1905-1909, of the commission that carried out the work. In 1906 he was a member and chairman of the commission which valued the Chicago street railway properties, and of all the subsequent traction valuation commissions of that city. He was consulting engineer of the Wisconsin Railway Commission 1905-7; member of the Erie Electric Traction Commission 1906-7; consulting engineer for Chicago to revise street railway systems, 1902-6; chief engineer 1907-11 and chairman 1907 to date of the Board of Supervising Engineers, Chicago Traction, to construct and extend the system at a present total cost of $145,000,000. He was also consulting engineer Public Service Commission, First District of New York, 1908-11, in matters connected with subway, street, and elevated railway properties in Greater New York. A vast amount of similar work has been done by him in Pittsburgh, Providence, Los Angeles, San Francisco, Toronto, Cincinnati, Seattle, Kansas City, Rochester, Des Moines, Harrisburg, Detroit, Flint, Winnipeg, Sacramento, Jersey City, Syracuse, Boston, New Orleans, etc. Mr. Arnold was chosen in 1913 by the Citizens' Terminal Plan for Chicago to review plans submitted by the Pennsylvania Railroad and other systems; and his recommendations, largely followed, resulted in the creation by the City Council of the Chicago Railway Terminal Commission to coördinate all such work. He was in Europe with this commission when war broke out in 1914 and witnessed the partial mobilization of the French, Belgian and British armies; thereupon suspending civil duties to give patriotic service. Other such work includes his retention as chairman of a Board of Advisory Engineers to the City of New Orleans to deal with the question of a bridge or tunnel for main line traffic across the Mississippi and for a terminal system coördinating local traffic, etc. This is a bare outline of a vast amount of such professional engagements, involving the responsibility for the expenditure of many millions and reports and valuations on properties aggregating over one billion dollars.

One of his chief characteristics is to keep in advance of his profession and, in the electrical field he has been the means, either by his own inventions or by the strong advocacy of the unproven inventions of others, of four very distinct advances of the practical application of electricity, as follows:

The use of the storage battery as an auxiliary in power plants, as first used by him in the plant of the Chicago Board of Trade.

The adoption of the A.C.-D.C. system for electrical railroading, as first put into use by him on the Chicago & Milwaukee Electric Railway, where he took the engineering and financial risk to prove the idea practicable, and which reached its highest development in the great New York Central Railroad Company's installation of its New York terminal.

The development of the single phase A.C. electric railway system, as first adopted by him for heavy electric railway work on the Port Huron tunnel of the Grand Trunk Railroad.

The development of the automatic substation for electric railways, as first developed and installed on the Elgin & Belvidere Electric Railway, a property owned by him.

Besides being a prolific inventor in elec-

trical and mechanical fields, Mr. Arnold has always had a keen interest in aeronautics on the inventive and experimental sides, being a member of the World's Fair Committee on Aeronautics of 1893; an observer of the celebrated Chanute experiments on Lake Michigan; and himself an experimenter on a farm he bought for the purpose, at St. Joseph, Mich. He gave a prize for the International Balloon Race held at Chicago, July 4, 1908; saw the first flight of Orville Wright at Fort Myer; and was with Wright and Selfridge just prior to the fatal flight when the latter was killed and the former injured. He was a director of the Aero Club of Illinois at the time of the Gordon-Bennett race at Chicago, 1912; was president of the club, 1912-13.

Col. Arnold was commissioned Major in the Engineer Officers Reserve Corps, January 17, 1917, as number 6 in the first list of commissions granted; became Lieutenant Colonel, Aviation Section, U. S. Signal Corps, December 14, 1917, accepted the commission December 24 and continued in active service first with the Equipment Division of the Air Service, then with the office of the Second Assistant Secretary of War, Washington, D. C., and later in the Department of Military Aeronautics in command of the development of the aerial torpedo. His duties in this connection giving him an experience of something over 2,000 miles in cross-country flying. He was honorably discharged February 6, 1919, and was made full Colonel in the Air Service Reserve Corps on September 13th.

In addition to his direct professional and patriotic work, Colonel Arnold has always given service to professional societies, etc., without stint. He is a Fellow of the American Institute of Electrical Engineers (president 1903-4), delegate to the International Electrical Congress, Paris, 1900; member of the Naval Consulting Board, U. S. A.; member and vice-president American Association for the Advancement of Science; vice-president and chairman of the executive committee, International Elecrical Congress, St. Louis, 1904; chairman Joint National Committee on Electrolysis, U. S. A.; member (president 1906-7) Western Society of Engineers; member American Society of Automotive Engineers; chairman of the committee representing the American Institute of Electrical Engineers on the organization of a National Reserve Corps of Civil Engineers for the Army, thus assisting to frame the Officers' Reserve Corps Act. Member of the board of trustees, Lewis Institute, Chicago; trustee of Hillsdale College, Mich.; past president alumni associations of the University of Nebraska, Hillsdale College and Cornell University; received gold medal for personal exhibit, Omaha Trans-Mississippi Exhibition; also diplomas and medals Buffalo Pan-American Exposition, St. Louis World's Fair, 1904, Franklin Institute, Philadelphia; chairman A. N. Brady medal commitee in American Museum of Safety, etc., etc. Member Electric, Midday, South Shore Country, Union League (director), Press Clubs, Chicago; Engineers' Club, New York City; Aero Club of America; Aero Club of Illinois (president) 1919; and has just been made president of the Air Board of Chicago, a body composed of the leading organizations of the city and fostered by the City Council, for the purpose of making Chicago an important air post and air craft center.

CHARLES GILMAN ATKINS

Charles Gilman Atkins was born February 16, 1865, at Tiffin, Ohio, son of Benjamin Gilman Atkins and Mary Busby Heming, father being of Irish birth and mother a "Buckeye" of English descent. On September 20, 1904, he was married to Rose A. Hoskinson, who was also a native of the "Buckeye" state.

He spent the usual allotment of time in the public schools of his native town, to within a few weeks of graduation, when an incident occurred which exerted a great influence on his going into engineering work, viz: The superintendent of the public schools received an application for three boys of a mechanical turn of mind to become candidates for the position of electrician of the local Edison electric light plant, and it was his good fortunte to be chosen. This was in the spring of 1884 when the starting of a central station for incandescent lighting and especially a station with the wonderful name of "Edison" connected with it, created a genuine stir throughout the surrounding country.

During his school years at Tiffin, he spent most of his vacations in the different departments of the Tiffin Agricultural Works, of which his father was president, and thus added to his inclination towards mechanical pursuits.

After a service of about three years in the electrical lighting plant, and the shops just mentioned, he left Tiffin to enter the Engineering Department of the Ohio State University and the period spent there covered the fall of 1886 to January, 1888.

From early in 1888 to the fall of 1889 he was employed in the field and office of the Ohio Canal Commission, which was engaged in a topographical survey of the canal systems of the state.

In the fall of 1889 he went to the University of Michigan and after a residence of seven semesters completed the required amount of work in February, 1893, graduating B.S. (E.E.) in June, 1893.

He then went to Pittsburgh and entered the Westinghouse Electric Mfg. Co. as a "student," where he was shortly stationed in the main testing room, and this work so appealed to him, that he remained about two and one-half years. In

CHARLES G. ATKINS

this period he had, in turn, charge of the several departments in the testing room, and during the latter part of the period he was made first assistant to the chief engineer of the testing department, and was closely associated with the designing of the layout of the testing facilities, in the new works of the Westinghouse Co. at East Pittsburgh.

For a few months Mr. Atkins was a district engineer for the Westinghouse Electric Mfg. Co., with headquarters at Boston.

In the spring of 1896 he went to Chicago and entered the employ of the Chicago Edison Co., spending about one year in the drawing room, being closely associated with the developing of the very

earliest installation of this company for the transmission of energy from point to point of their low tension D.C. systems, by means of intervening high tension A.C. systems.

For about three years he was superintendent of the Chicago Edison shops and he considers this part of his career as unusually valuable in an educational way, for the work consisted of maintenance in connection with power plant machinery.

For the latter part of his career with the Chicago Edison Co., he was "power engineer" to the contracting department in which capacity he made studies of the economics of isolated plants in the city, and while at this work he became interested in an independent career as a consulting engineer and August 1, 1901, went into a partnership with Mr. C. A. Pratt, an established consulting engineer with offices in the Monadnock Block, Chicago. The firm continued and enjoyed a successful practice. Upon the withdrawal of Mr. Pratt from the firm, Mr. Atkins succeeded to the business. His work has continued along the same lines and consists, briefly, of the complete electrical and mechanical equipment of business buildings and industrial plants, of which there are many examples, most of them being within the limits of the city of Chicago. More in particular, his work has been in connection with club buildings, hospitals, printing and publishing companies, machine shops, foundries, tanneries, etc.

WILLIAM A. BAEHR

The old idea and plan of developing public utilities based in each case on the supply of only one necessity of life was certainly primitive, and the wonder is it carried through as far as it has done. In some instances the utility is so large it can stand by itself and demands the best concentration of executive and engineering management; in other instances, political or economic conditions have stood in the way of an otherwise obviously desirable consolidation. But in the great majority of instances a careful study of the field shows that grouping the utilities in any chosen locality or region has always had much to recommend it. The history of such development in the past twenty-five or thirty years would have been paralleled not only by the overdone competition in the produce field of, say, two stores where one would suffice and prosper, but by the absurd restriction of effort to a limited product so that not only were there two groceries, but six, because some would handle only vegetables, others creamery articles, others bread and flour specialties; and others again would deal only in refined sugar. From such needless multiplication and specialization, in the utility field there has been a decided recoil; and by some leaders the reaction has been carried very far and very successfully.

Among those who have been identified with this healthy process of securing better return on investment, better service to the public and better economics in plant operation, is Mr. William A. Baehr, of Chicago, whose later career is closely and largely identified with the acquisition, consolidation and operation of various public utilities, principally electric light and power, but not forgetting artificial ice and gas plants. His controlling idea has been to form groups of such properties, replacing inefficient, ill-located plants by large, centrally-located efficient ones, tying them in by transmission lines and reticulating a much larger territory with the service formerly available only on poorer terms in smaller areas. It is a worthy mission in life to give oneself such a "mandate" as that.

Mr. Baehr was born at Oshkosh, Wis., September 15, 1873, and had the distinct advantages of perfecting studies for his future work at the University of Wisconsin, where he graduated in 1894, from the Civil Engineering course; his fraternity being Beta Theta Pi. Men from "Wisconsin" have little difficulty in locating anywhere in the country, so noticeable is their training and proficiency, but Mr. Baehr began near home, at Milwaukee, in structural engineering. However, he was

WILLIAM A BAEHR

soon attracted by the vast opportunities of usefulness in developing sound public utilities, so responsive to a desire to do something socially constructive. Hence, in 1877, he "threw his hat" into the public utility arena, and began at once to put his theories and abilities to the test. In this way he came to design and construct a number of plants and transmission systems, and in due course to develop a number of "groups" of such enterprises along the synthetical lines indicated above. Without going into a variety of detail, it may be noted that Mr. Baehr's professional career has included specific terms of service as superintendent of distribution, Milwaukee Gas Light Company; superintendent, Gas Department, Denver Gas and Electric Company; chief engineer, Laclede Gas Light Company, St. Louis, Mo.; president, North American Light & Power Company, also president of each of the affiliated and subsidiary companies. He has also been, as now, consulting engineer for numerous gas and electric lighting companies, and for about a year was consulting engineer for the Public Service Commission, First District, New York City, in connection with gas pressure regulation on Manhattan Island. He has, of course, been in practice as a consulting engineer under his own name, and his work naturally brings him in intimate relations with many public and corporate enterprises. In addition to this engrossing occupation, Mr. Baehr has taken a very active interest and share in the development of by-product coke ovens, with correlated utilization of waste heat in the generation of electrical energy.

Although a native of the Badger State, where his parents settled long ago in the pioneer days that saw the breaking up of the soil of the great western prairies, Mr. Baehr's interests, like those of so many others of similar origin, have centered around Chicago, with offices in the Peoples Gas Building and residence at 360 Palos Road, Glencoe, Ill. It follows that many of his professional and social affiliations are there to be found, as a member of the Union League of Chicago, the Chicago Electric Club, the Chicago Athletic Association, the Skokie Country Club of Glencoe. He is also a member of the American Society of Mechanical Engineers, the American Gas Association, the National Electric Light Association, the Western Society of Engineers, etc. Relief from pressing professional cares and duties is found in such recreations as golf and mountaineering.

ROBERT H. BARCLAY

Robert Hamilton Barclay, Electrical Engineer of The Foundation Company of New York, is a product of the middle West. He was born in St. Louis on August 10, 1887, of a family prominent in professional circles in that city since its early settlement. Since he became active in the field of electricity, his work has taken him to many different fields, within territory bounded by San Francisco on the west, Nova Scotia on the east, Montreal on the north, and Valparaiso, Chile, on the south.

Mr. Barclay's electrical training really began at the age of eight years, when a liking for mechanical toys led him into the primary stages of an experimental study of electricity. Experimentation continued during his primary school education until his entrance into the St. Louis Manual Training School, from which he was graduated in 1906. Vacation periods during his time in school were spent in obtaining practical experience in the employ of the electric light and power companies of St. Louis, as trouble man, meter tester, sub-station operator and general electrician. His technical training was obtained at Washington University, while he continued to enlarge his practical experience by continuing his vacation employment with the power company.

In 1908 he entered the employ of the engineering department of the Bell Telephone Co. of Missouri, of which he eventually became chief draftsman, after which

he was transferred to Kansas City as superintendent of power plants and buildings for the Missouri & Kansas Telephone Co. That was in 1910, and two years later he resigned to accept a position as assistant electrical engineer of the Kansas City Terminal Railway Co. In that capacity he was instrumental in designing and installing the electrical services for the $6,000,000 Union Railway passenger station at Kansas City.

Upon the completion of the big depot in 1915 Mr. Barclay came east to enter the employ of the Brooklyn Rapid Transit Co. in connection with the engineering and construction of the electrical services in the dual subway system of New York and Brooklyn. Here he developed, among other things, a system for employing the combined carrying capacity of several third rails on parallel tracks, so connected that any set of rails could be grouped together at the tracks by the operation of remote control switches at the sub-stations, with a further safety provision for disconnecting equalizer and feeder connections to any particular rail in case of accident in the subways.

The Foundation Company enlisted his services in 1917 to take charge of and develop its electrical engineering department. This work has embraced the designing and supervision of construction of the electrical operations of all jobs executed by his company since that date. Among the notable contracts thus supervised were: the plant of the Dunlap Tire & Rubber Corp. of America at Buffalo, N. Y., with a capacity of 12,000 auto tires a day; the $5,000,000 plant of the International Nickel Co., Ltd., at Port Colborn, Ontario, Canada, and the construction, during the war, of two powder bag loading plants for the United States Government at Tullytown, Pa., and at Richmond, Va., each covering an area of approximately 1,500 acres.

This company also had fourteen shipyards in operation during the war, and constructed a number of power plants varying in capacity from 1,200 kw. to 25,000 kw., the electrical divisions of which were designed and constructed under his direction.

Mr. Barclay is a member of the American Institute of Electrical Engineers, the Jovian Order, Theta Xi Fraternity, and the Columbia Yacht Club of New York.

PHILANDER BETTS

Born at Nyack, N. Y., May 28, 1868, Col. Betts' center of gravity has always been New Jersey, for while his paternal ancestors were all from western Connecticut, his maternal were French and Dutch settlers in the Hudson and Hackensack River Valleys and that includes northern New Jersey. He was also graduated from Rutgers College, New Brunswick, B.S., in 1891, and it conferred an M.S. on him in 1895. His college fraternities are Beta Theta Pi and Theta Nu Epsilon. He has moreover taken special courses at Columbian University, E.E., in 1903, and George Washington University, Ph.D., 1914.

Col. Betts entered the electrical field at an early stage of its modern development, being one of the pioneer construction engineers for the Field Engineering Company, a natural course for one whose forebears had been pioneers in the operation of the Erie Railroad, although his father was a sanitary engineer. Mr. Betts' early work dealt chiefly with the electrification of existing street railways in Newark, Orange, and South Orange, N. J., the Schuylkill and Luzerne Counties, Pa.; Philadelphia and Pittsburgh. This was but a beginning. Other work may be noted as follows: electric railway efficiency tests on interurban lines, 1894; and on all the Washington, D. C., trolley lines 1902-5; special investigations for the York Railways Company and Edison Electric Light Company, York, Pa., 1908-9; work for the Westinghouse Electric & Manufacturing Company, 1893-5; Lakeside Railway Company, 1894; electric engineer Washington Navy Yard,

R. HAMILTON BARCLAY

1895-1900; mechanical engineer Bureau of Yards and Docks, designing and testing pumping plants and central stations for new dry docks, 1901; contract engineer, Potomac Electric Power Company, 1901-5; consulting engineer, Washington Railway & Electric Company, 1902-7; instructor and later assistant professor in electrical and mechanical engineering,

LT.-COL. PHILANDER BETTS

Columbian (George Washington) University, 1900-11; consulting engineer, public utility systems, York, Pa., 1907-10; chief engineer, New Jersey Board of Public Commissioners 1910-20. Col. Betts was responsible for the methods employed in copper plating steel guns at the Washington Navy Yard; as well as for the development of the present method of electrotyping employed by the U. S. Coast and Geodetic Survey.

Col. Betts having always taken an intense interest in preparedness, and with four years' military training in college, found a new opportunity in the Great War and served in the Army in important administrative capacities from July, 1917, to June, 1919. He was an instructor in the Engineering Division of the Naval Militia, D. C., for two years; helped organize the Engineers' Training Battalion in New York and at Plattsburg Camp, N. Y., 1916; became Major in the Engineers' Reserve Corps, 1917; Lieut.-Col. Quartermaster's Corps, March, 1918, to June, 1919; and was re-commissioned Lieut.-Col. E. R. C., August, 1919.

Col. Betts has never held political office, but organized the engineering work of the New Jersey Commission when there were but two other such public utility regulatory bodies in the country. He has developed methods for continuous inventory and appraisals now followed, and has consistently insisted on the recognition of all elements of historical cost in fixing rates, capitalization, etc. He is a Fellow of the A.I.E.E. and member of the A.S.M.E.; the I.E.S.; the A.E.R.A.; the A.A.A.S.; the American Association of Engineers, and the New England Water Works Association. He is also a member of the Society for Constitutional Government; founder member Washington Society of Engineers; member the S.P.E.E.; the Construction Division Auxiliary, U. S. Army; Montclair Battalion, Montclair Rifle Club; American Legion; National Rifle Association; charter member, Officers' Service Club, Washington; Past Commander, Newark Chapter, Military Order of the World War; Society of American Military Engineers; and a thirty-third degree Mason. His residence is 100 Tenth Ave., Belmar, and his office may be said to be that of the New Jersey Board of Public Utility Commissioners at Newark and Trenton.

ROBERT N. BAYLIS

Mr. R. N. Baylis was born at Englewood, N. J., March 16, 1867, was educated in private schools and at the Stevens Institute of Technology, graduating in 1887, serving for three years as president of class. His fraternity is Delta Tau Delta.

ROBERT N. BAYLIS

Beginning his professional career in the shops of the Southwark Foundry & Machine Company of Philadelphia, he soon passed into the electrical field, first with the C. & C. Electric Company, of which he became chief engineer, and then with the Walker Company, Cleveland, as designer of electrical railway apparatus, chief electrical engineer and expert in patent litigation. In 1893 he was also engaged at the Chicago World's Fair in electric and steam power testing. In 1897 he organized the Baylis Company of New York and Bloomfield, N. J., to manufacture, as its president and works-manager, "Reaction" carbon brush holders and brushes of his own invention as well as his gas pressure regulators and other specialties, all in growing application, and the former being widely adopted for electrical machinery over a period of 25 years. Outside of these, Mr. Baylis has devoted his time and studies largely to biology and sociology, but has found time for public service, and during 1905-8 was president of the common council of his native city.

Mr. Baylis is a member of the American Institute of Electrical Engineers, American Society of Mechanical Engineers, Stevens Alumni Association and Delta Tau Delta Society. His business headquarters are in Bloomfield.

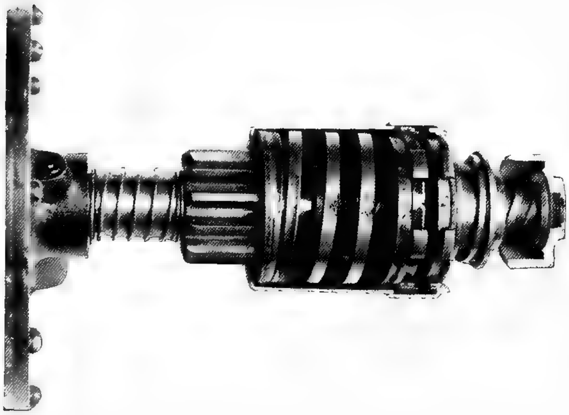
JOSEPH BIJUR

Joseph Bijur, President of Bijur Motor Appliance Co. of Hoboken, N. J., was born in New York City, April 15th, 1874. Entering the School of Arts at Columbia University in 1889, he won honors in mechanical subjects, a scholarship in Physics and graduated with the degree of A.B. in 1893. At that time he was tendered the Tyndall Fellowship in Physics, involving several years' study abroad, but declined it in order to study electrical engineering at the same University. This course required four years, but studies completed during his Academic course, and work outside of the regular sessions, enabled him to graduate two years later with the degree of E.E.

Mr. Bijur served in an engineering capacity with the Ward Leonard Electric Co., manufacturing rheostats, etc., then

JOSEPH BIJUR

with the Electric Arc Light Co. of New York, in the production and marketing of enclosed arc lamps. He was instrumental in bringing about a consolidation of this Company with others in this field, and later joined the Walker Co. of Cleveland as a salesman, subsequently becoming manager of its plant at New Haven, making arc lamps and switchboards, until the company was absorbed by Westinghouse interests. After a year as assistant chief engineer at the plant of the Siemens and Halske Co. in Chicago, Mr. Bijur decided to engage in the development of a storage battery of his own invention. He formed the General Storage Battery Co., of which



THE BIJUR AUTOMATIC SHIFT

he became President, and equipped a plant for it at Boonton, N. J., where he installed a hydraulic power plant of several hundred horsepower with a steam reserve of equal capacity.

From 1899 to 1909 he devoted himself to the conduct of the storage battery company, which acquired the largest share of the railway train-lighting business as well as a considerable amount of power-plant work. During this period he made numerous improvements in electrochemical processes for batteries, and in automatic machinery for their manufacture; also in cell switches, boosters and regulating appliances used in conjunction with them.

Of these developments, which attained wide commercial use, perhaps the most noteworthy was the "Permanized" negative Planté plate.

In storage batteries of this type, in which the active oxide layers are not applied to the plates as paste, but are electrochemically formed out of the metallic lead of which the plate is composed, there had always existed a serious defect in regard to shrinkage of capacity in the negative or spongy lead elements.

Whereas, in batteries where the oxide is applied as paste, it had been possible to overcome this defect by an addition of a small percentage of inert material to the mass, no remedy was available for plates whose oxide was grown or formed out of the metal. Mr. Bijur's invention consisted of impregnating the pores of the sponge lead by dipping the completed negative plate into a solution which, when dried, left a material in the pores, that by subsequent treatment was converted into insoluble and inert form. A similar discovery was made independently by engineers of the Storage Battery Department of the Westinghouse Machine Co. The General Storage Battery Co. prevailed in the Patent Office interferences which resulted, and the two companies consolidated their interests in the Westinghouse Storage Battery Co., which occupied the works at Boonton under Westinghouse management. A year later, the plant was completely destroyed by fire, and the patents and good-will sold to the Electric Storage Battery Co. of Philadelphia.

Mr. Bijur, who had remained active as a director of the Westinghouse Co., was also engaged, in a consulting capacity, in developing train-lighting apparatus for the Safety Car Heating and Lighting Co. of New York, and under his direction there were developed the appliances which this company has since used in its extensive business.

While so engaged, he secured the rights to some of his inventions for use on gas-propelled vehicles, and in 1910 embarked in the development of electrical equipment suited to such use.

This work was carried on by the Bijur Motor Lighting Co. and later by its successor, the Bijur Motor Appliance Co., of which Mr. Bijur is President, and in which the General Electric Co. is largely interested. In this line there were developed, either by Mr. Bijur or under his direction, many articles which have come

into wide commercial use. First came a unique type of vibratory voltage regulator in a condensed form, small enough and sufficiently rugged in character to be attached to a small generator mounted on the automobile engine. Then, when electric current came into general use for automobile lighting and was available for starting the engine, his firm developed a line of small electric motors for this purpose as well as automatic means for coupling and uncoupling the electric motor to the gas engine upon merely closing the circuit to the motor. Mr. Bijur was granted broad patents on this device and almost all cars manufactured at the present time carry either the device made by his company or one manufactured under its patent license. In his company's device, marketed under the name of "Bijur Shift," the starter pinion is automatically slid or shifted along the motor shaft so as to become engaged with or disengaged from the engine flywheel, and the motion results from the action of a screw thread cut on the shaft, on a nut influenced first by inertia, and subsequently by the rapid rotation of the flywheel of the engine when the latter begins to revolve. Thereby a toothed pinion on the motor shaft, upon the mere starting of the motor, is caused to slide along the shaft and mesh with a toothed ring on the engine flywheel, the engine is revolved or "cranked" by the electric motor until the engine starts, whereupon the pinion automatically slides along the shaft in the opposite direction until it is out of mesh, and remains there until the electric motor again comes to rest. The parts are enclosed in a barrel or cylinder which serves also to hold and rotate the pinion, and the barrel is turned by a self-tightening clutch of simple construction which is clamped by the nut so that the shock of connecting the rapidly accelerating motor to the stationary flywheel is absorbed without shock to the parts.

Another device of the same company is an electric starter for airplane engines, developed during the World War and first applied to the Liberty engine. One form of this starter is adapted to be mounted on the engine next to the propeller or air screw. On this is mounted a light steel gear ring with which the starter automatically engages by means of a mechanism different from the standard "Bijur Shift," but also using the screw principle. Another type of starter, for the opposite end of the engine, is adapted to engage the end of the engine crankshaft and so rotate the engine. Both embody ingenious mechanism of a great strength and lightness and are practically the only electric starters in use on airplane engines. They were fitted to the engines of the N-C flying boats which first made the flight across the Atlantic, were adopted as standard by the U. S. Army and Navy, and have come into wide use on many engines and planes.

Numerous other devices developed by Mr. Bijur or his company have become prominent in the field of electrical equipments for automotive engines, and the manufacture of this line has been taken up in Europe.

Mr. Bijur married Alice Pronick in 1896, has a son studying mechanical engineering at Worcester Polytechnic Institute, and is an ardent devotee of golf as his principal recreation.

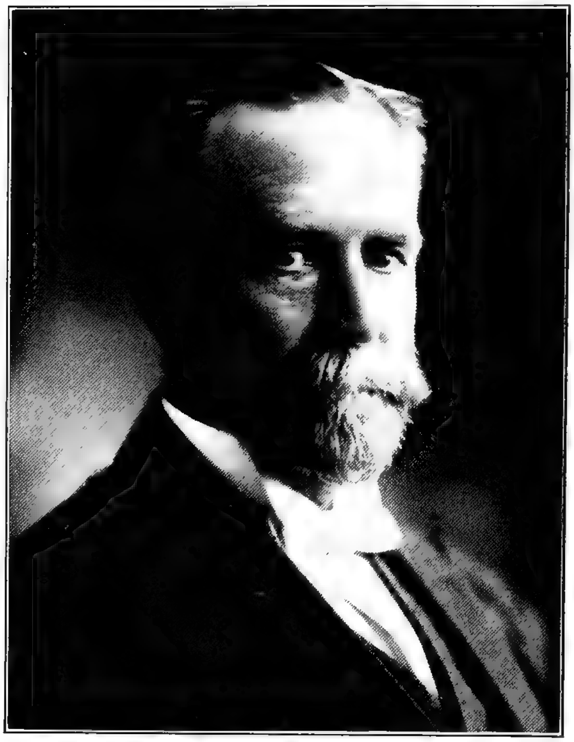
H. A. CAMPBELL

Christmas day is probably as good as any in the year for a birthday, and was selected with characteristic good judgment by Mr. H. A. Campbell, who first saw the light at Metuchen, N. J., and who for forty years past has been very busy in helping to furnish to the world the light of his great chief, Thomas A. Edison. He is a graduate of "the little red school house" with its one teacher to about one hundred pupils ranging from 5 to 21 years, and does credit to that venerable American institution. Soon after leaving school in 1869, he started to learn the carpenter trade, having mastered which he launched out into the saw-mill industry, sawing up wood for all kinds of use. In 1877 he blossomed out still further taking on carpentering work, contracting, etc. He had now reached the great "psychological moment" of his career, as may well be told in his own terse summary.

"October 24, 1878, started work for Mr. Edison at Menlo Park, doing general carpenter work. I built the little station for them and set up the Z dynamos that fed current to some 500 lamp-posts in the streets of Menlo Park. I also set the posts themselves for the lighting. I then helped put down his first electric road, and laid the ties ready for the rail. I was next made superintendent of construction to fit up the lamp works (first in the world), with new engines, boilers, etc., a dynamo building, and an addition to the old building, fitting it all up for lamp blowing, etc., so as to complete the manufacture of the first commercial Edison incandescent lamps. In the summer of 1881 I started to remodel and fit up the building at Harrison, N. J., for Edison lamp works, now occupied as part of the great Edison lamp factory of the General Electric Company.

"On August 19, the same memorable year, 1881, I was called to New York by the New York Edison Electric Illuminating Company, to take charge as superintendent of construction, fitting up the famous 'First Central Station' at 255-257 Pearl Street. I had charge of installing and completing everything put in the station under Messrs. C. L. Clarke and J. L. Hornig. I remained with them until May 30, 1883, when my little part was complete, and the station was running nicely under Superintendent Cashio.

"I then went back to old Metuchen, to



H. A. CAMPBELL

my contracting and building, but in the Fall of the same year, I was called up to remodel a private electric lighting plant of the Edison system in the stables of Mr. John Pierpont Morgan, to stop noise, vibration, smoke, etc. It was a short job, under contract, and then I retired again to New Jersey—but they wouldn't let me alone. June 16, 1886, I was called up by telegram to go to New York at once, where I found I was wanted to fit up at 60 Liberty Street, an annex to old 'Pearl Street.' Next day I gave them the figures, and I was immediately awarded the contract. I was to complete all work ready for the engines and dynamos to be set on their foundations in 30 days, clear-

ing out the basement, underpinning the sidewalls of the building, and putting in two engine foundations and four dynamos. Steam was taken from the New York Steam Heating Company.

"I now remained with the New York Edison System, doing its light construction. In 1887 the company started a wiring department, to do the work at cost, and to develop business for the plant. Contractors were very few in those days, and were generally charging high prices, blocking the growth of the business. I was given charge of all wiring in the district and ran the department until it was closed up, a number of good contractors having entered the field.

"That was about 1890. I was then offered the position of assistant superintendent of the Pearl Street station and accepted it. In 1893 I was made superintendent and sent to the Second District—Eighth Street and Fifty-ninth, river to river—where I have since remained. There were then three stations in the Second District with a load of about 20,000 amperes at 120 volts. Today we have eleven stations with a maximum load of 900,000 amperes, or about 108,000 kilowatts, and the end is not yet, by any means."

And when not preoccupied by all this share in a colossal development, Mr. Campbell is busy with his little farm and dairy at quaint old Metuchen, and in making plans whereby workingmen can get homes of their own.

H. E. CHUBBUCK

Closely linked with the story of electricity and its application to the practical uses of the day is the family name of Chubbuck.

Back in 1844 when the first telegraph message was flashed from Washington to Baltimore, the instruments used in sending and receiving the sentence that was to spell a revolution in methods of communication were being made by Samuel Winchester Chubbuck in his little shop in the village of Morrisonville, N. Y. For some time previous to the first trial this talented New Englander, who was a student of science and gifted in the art of fine work with tools, had been collaborating with Professor Joseph Henry in his researches and was developing the instruments which later were to supersede the crude affairs on which Morse secured his patents. His instruments were used by request of Morse and his colleagues for the extension of the trial line from Baltimore to New York, and for the first line from Albany to New York.

For many years after the first trials there were constructed in the Chubbuck factory in Utica, N. Y., practically all of the telegraph machines used in the United States and Canada. Here Samuel Chubbuck, with the assistance of his son, A. S. Chubbuck, worked out and developed many refinements in use today, including first the register and then the "pony" sounder and key, all of which added greatly to the utility and practicability of the telegraph. Of these improvements, the "pony" sounder was probably the most important, as it made possible the instantaneous recording of the message on the ear of the operator by sound in place of the crude method of transcribing the dots and dashes by pen on a movable strip of paper. The idea of the "pony" sounder was that of the elder Chubbuck, but it was worked out and developed by his son.

Previous to the "pony" sounder the Chubbucks had greatly simplified the early telegraph machines by substituting a clockwork arrangement for moving the strip of recording paper in place of the cumbersome system of pulleys and weights with which their first machines were equipped. For this improvement to the telegraph machine the elder Chubbuck had been awarded a medal at the Utica Mechanics Fair. Following the "pony" sounder came the invention and development in the Chubbuck factory of a machine for covering the wire with silk thread; the circuit closer and key in use today; as well as the binding post now used on all instruments and battery connections.

Samuel Chubbuck's mechanical ability was not confined to the development of

H. E. CHUBBUCK

the telegraph. He was a pioneer among the scientific adventurers of the days when electricity was beginning to emerge from a state of theory, and was probably responsible for the proving out of as many original and successful scientific theories as any of the men of his time. As a young man he worked at the manufacture of scientific, mathematical and philosophical instruments for schools and colleges and his shop soon became noted for the excellence of its work along these lines. He was a student of chemistry, and constructed chemical and optical apparatus, as well as fine surveying instruments. While his name has not been generally associated with the commercial success of electrical apparatus and appliances, it is a fact that his genius helped to solve many perplexing problems of the early days and to provide a basis for much of our modern electrical equipment. Although the originator of many patentable ideas, he never took advantage of such opportunity. He was interested in his investigations from the scientific rather than the commercial standpoint, and was willing to pass on his results for the enrichment of others.

As early as 1845, at some of the annual fairs and exhibitions in vogue in those days, he is credited with exhibiting an "electric machine," a magneto-electric machine, working model steam engine, rotary armature, revolving temporary magnet, optical paradox and Galvanic batteries, which is indicative of the versatility of his genius. He was noted in the lecture field and the story is told that during one of his lectures at Milan, O., he had as a part of his exhibition a model car propelled by an electric motor which was especially attractive to an eight-year-old boy who begged his father to remain after the lecture that he might more closely examine the workings of the model. This boy was Thomas A. Edison, whose mind was even then turning to the mysteries of that wonderful force with which he was to do so much for the world.

In the later years of the elder Chubbuck's life, his son, A. S. Chubbuck, took over entire charge of the telegraph instrument business. He had in large degree his father's skill and mechanical genius and used it to advantage in working out the details of the "pony" sounder and other improvements that created a demand for their superior instruments. His cooperation and support in the manufacture of the telephone had been enlisted by the promoters of this newly-invented instrument, when his death at an early age prevented carrying out ambitious plans and cut short a brilliant career.

Today the grandson of the man who was one of the first to experiment with electric current for communication and traction purposes is operating executive of one of the largest electric railway and electric utility operating companies in the United States. Where Samuel Chubbuck had the germ of an idea, it has been the privilege of his grandson, H. E. Chubbuck, to see and help put the theories of the early days into practice in his work as executive head of the Illinois Traction System. Growing up in the electric atmosphere and reflecting the mechanical genius of his family, he naturally turned to that vocation when he started his business career. At an early age he went as an electrical expert with the Thomson-Houston Company, of Boston, which was parent of the present General Electric Company. He built, rebuilt and managed electric light plants in the early days, installing the lighting systems at Pawtucket, R. I., Syracuse and Auburn, N. Y., and Springfield, O. He was then electrical engineer for the Narragansett Company at Providence, R. I., after which he again entered the service of the Thomson-Houston Company and managed the electric lighting plant at Springfield, O., which he had installed; and was then transferred to Omaha, Neb., where he reorganized the lighting system. The reorganization of the street railway at Pueblo, Colo., which had suffered from the panic of 1893, was his next work for the General Electric Company.

Mr. Chubbuck then became associated with William B. Mc Kinley, who was developing a system of public utility plants in the Middle West that has grown until now it includes an electric railway in the state of Illinois, with 555 miles of track, and supplies about 100 cities and towns in the states of Illinois, Iowa, Missouri and Nebraska with electric transporta-

tion, power and other utility service. The electric railway operated by this company, now known as the Illinois Traction System, is one of the most highly developed electric carriers in the country, and its president, William B. McKinley, has, after many years of service in Congress, been elevated by the people of Illinois to the honored position of United States Senator from that state.

His first connection with the Mc Kinley properties was at Quincy, Ill., where Mr. Chubbuck rebuilt the street railway and utility plants, and at the same time took charge of the company's utility plants in Galesburg, Ill. After bringing these properties to a high standard he was placed in charge of the development work being done by Mr. McKinley in the Illinois River valley, where he built and placed in operation about sixty miles of electric railway and in addition took charge of the operation of utility properties of the Western Railway & Light Company.

The Illinois Traction System, having by this time become an aggressive and important factor in the transportation and utilities field in the Middle West, Mr. Chubbuck was next transferred to Peoria, Ill., and made general manager of the entire McKinley system, including the Illinois Traction System, the Western Railway & Light Company and all component properties. Within a year he was made vice-president executive, which position he now holds, and in which capacity the grandson of the electrical pioneer, Samuel Winchester Chubbuck, is, today, one of the foremost men in the electrical industry.

EDWARD J. CONDON

In the practical application of electricity to public utility a great work has been accomplished by a class of contracting and construction engineers who have built and put into active operation lighting systems in the smaller cities of the country, giving them the urban advantages of good lighting service.

One of the best known of these engineer contractors is Mr. Edward J. Condon, of Chicago, to whom many of the cities of the Middle and Western States are indebted for excellent lighting service.

Mr. Condon was born in Cambridge, Mass., September 28, 1861. He was educated in the Boston public schools, and after that was engaged in various kinds of work, including three years, 1887 to 1890, in the United States Revenue Service.

He prepared himself by practical experience for engaging in construction work of a public character under contract, and he began in Chicago in 1895 to carry out a number of contracts for water, sewer, and other conduits for the city of Chicago, as well as cable laying and vault construction for electric light and telegraphs. He became associated with important contracting organizations and firms, being president of the Condon Construction Company, and a partner in the firm of Fitzgerald, Condon & Co., and Mahoney & Condon.

Having in these general contracting enterprises obtained advantages of capital and equipment he engaged as an engineer contractor in the building and rebuilding of public utility plants in the smaller cities of Indiana, Illinois, Iowa, Wisconsin and Minnesota, in many of which he obtained a controlling or large interest. Among these he is president of the Boswell (Ind.) Electric Light and Water Company; Waterloo (Iowa) Electric Light and Water Company, and Harvard (Ill.) Electric Light and Power Company. He is engineer for the Seymour (Ind.) Gas and Electric Company; the Madison (Ind.) Fuel and Light Company; Baraboo (Wis.) Gas and Electric Company; Nebraska City Gas Co.; Rochester (Minn.) Gas Company; Paxton (Ill.) Electric Company; and Villeoca (Iowa) Electric Light Company; and is also president of the Indiana Utilities Company. These are all well built plants engaged in a prosperous business in the lines of public service to which they are severally devoted.

Mr. Condon is a member of the American Institute of Electric Engineers, National Electric Light Association, Elks, Knights of Columbus, and "Jovians."

JAMES R. CRAVATH

James R. Cravath is probably best known by his work in illuminating engineering, although his engineering activities have covered a much broader field, and for many years his principal work was in electrical journalism. He was born in 1872 at Grinnell, Iowa, and graduated, B.S., from Grinnell College in 1892. From 1900 to 1910 he was on the editorial staff of the *Electrical World* at Chicago, his work being largely among electric light and power interests, and his most important contribution to the art being his extensive study of central station economics and management. Realizing the importance of improving on the common methods of utilizing light, he was one of the first to commence the study of illuminating engineering, in which his advice and writings soon became in demand. In 1910 he left editorial work to open an office as consulting engineer in Chicago. His pioneer work in lighting has included the design of reflectors of many new types for both direct and indirect lighting, invention of new

lighting units, reduction of illumination calculations to a more definite and satisfactory basis, investigation of eye strain under different lighting conditions, the application of various practical methods to avoid strain, and the improvement of automobile headlighting. He is the author of many papers and several books on illumination matters.

In 1921 Mr. Cravath removed from Chicago to Richmond, California, where he became president of the Pioneer Electric Company, engineers and contractors, and dealers in electrical motors and lamps.

HENRY J. CROWLEY

Henry J. Crowley was born in Unionville, Conn., in 1865. His boyhood was spent in that State on a farm in Avon Township. Upon graduation from high school he entered the employ of the Pratt & Whitney Company, of Hartford, Conn., serving an apprenticeship in mechanical engineering. After completing his apprenticeship he entered the locomotive shops of the New York, New Haven & Hartford Railroad Company located in Hartford.

About 1882 the Schuyler Electric Light Company was organized, with Spencer D. Schuyler as President, locating their factory at Hartford, Conn., to manufacture arc and incandescent lighting apparatus and all articles pertaining to the industry used at that time. After passing through all of the Schuyler Company's departments, including the testing department, he later assisted in a number of lighting installations throughout New England and Pennsylvania, and was then placed in charge of all installations of the company west of Pittsburgh. During this period Mr. Crowley installed the original lighting plants at Canton, Massillon, and Worcester, O.

In 1888, after the Thomson-Houston Electric Company purchased the Van Depoele Electric Railway System, he entered the employ of the latter company and was intimately associated with the late Charles J. Van Depoele in the early development of the Thomson-Houston Company's electric railway system. The following year he was appointed chief of experts of Thomson-Houston Company, having charge of the students' course at the Lynn factory.

From 1890 to 1893 he was manager of the railway department of the Company's southern office with headquarters at Atlanta, Ga. During this period he was in charge of a number of the early electric railway installations, including roads in Atlanta, Macon, Augusta and Savannah, Ga., Birmingham and Mobile, Ala., and Chattanooga and Memphis, Tenn.

During the period from 1893 to 1899 he was Engineer and Manager of the General Electric Company's railway department in the eastern district, which included southern New Jersey, Pennsylvania, eastern Ohio, Delaware, Maryland and North Carolina, with headquarters at Philadelphia. During this time he was actively engaged in a number of railway installations, among the more important being Philadelphia, Pittsburgh, Harrisburg, Baltimore, Washington and Richmond.

When The American Railways Company was organized in 1899, Mr. Crowley was elected General Manager of this Company, which position he now occupies, being in direct charge of the engineering construction and operation of all of the Company's subsidiary properties. This Company owns and operates approximately thirty electric railway, electric light and gas companies in twenty-four locations in twelve different states.

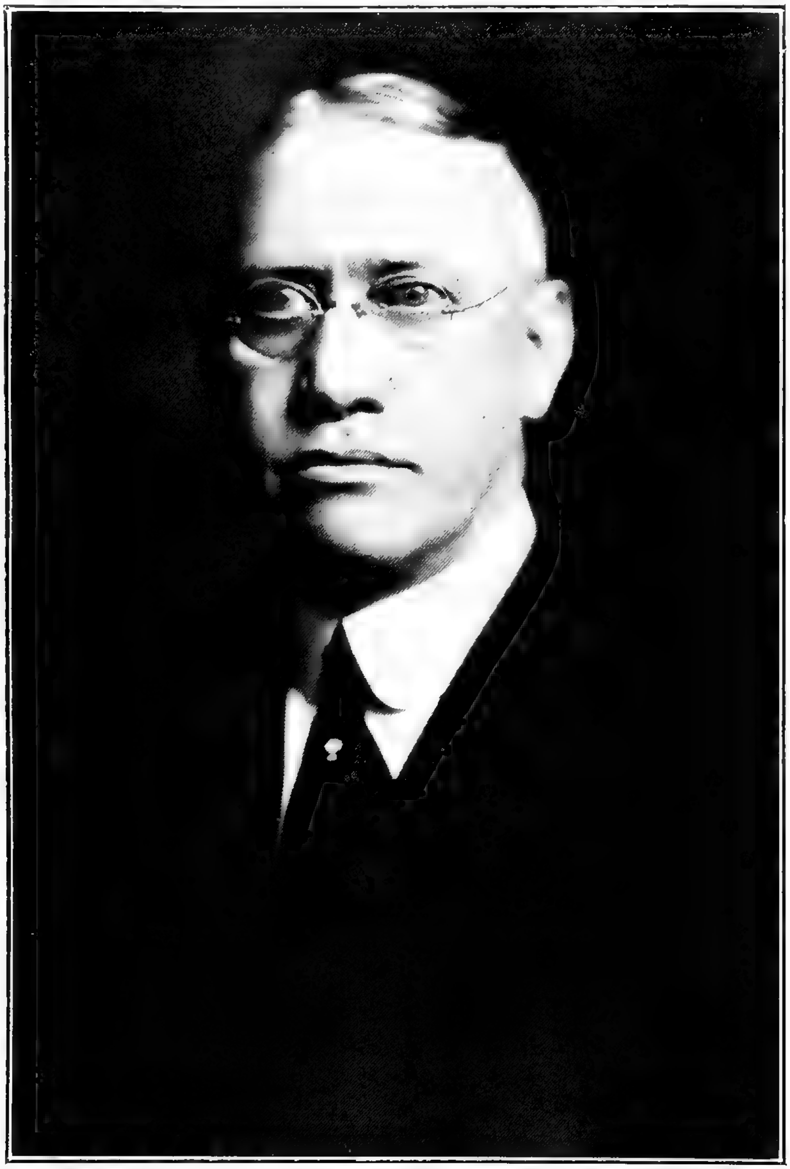
During the Spanish-American war, Mr. Crowley organized a volunteer electrical corps and had charge of the placing of submarine mines, searchlights, telegraph and telephone connections at Fort Delaware in the Delaware River opposite New Castle, Del., under the supervision of the late Major Raymond, United States Engineer in charge of this district.

Mr. Crowley is a Fellow member of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers.

HENRY J. CROWLEY

DAVID FRANCIS CRAWFORD

Mr. Crawford was born in Pittsburgh, December 4, 1864, and was educated at public and private schools and at the Pennsylvania Military Academy. He has an honorary degree of Doctor of Engineering from the University of Kentucky and is an honorary member of the Tau Beta Pi.



DAVID FRANCIS CRAWFORD

In 1886, Mr. Crawford became an apprentice in the famous machine-shops of the Pennsylvania Railroad Company at Altoona, Pa., and he acquired a useful fund of knowledge and skill, being made an inspector in the test department in 1889, including electrical work, then becoming very important. In 1892, he was made assistant master mechanic at the Fort Wayne Shops of the Pennsylvania

Lines, with special reference to electrical equipment. In 1895 he was assigned to special duty at the works of the Westinghouse Electric & Manufacturing Company at Pittsburgh, and in the same year was made assistant superintendent of motive power of the Pennsylvania Lines. In 1899 came another change and step when he was made superintendent of motive power of the Northwestern Pennsylvania System lines; but once more this had reference more particularly to electrical work, and included electric car lighting, which was then beginning to attract considerable attention in the railroad field. In 1903, Mr. Crawford found himself general superintendent of motive power, Pennsylvania Lines west of Pittsburgh. Other important work came, as he was made a member of the Committee on Electrification of the great new Pennsylvania Terminal in New York City, as well as member of the committee to design electric locomotives for the Pennsylvania Service at that vital point. As in other instances, notably on the Pennsylvania System, such constantly engineering preferment and distinction brought wider executive work and in 1917 Mr. Crawford was made general manager of the Pennsylvania Lines west of Pittsburgh. In 1918, he was elected vice-president of the Locomotive Stoker Company. He is also President of the Westinghouse Union Battery Co., having been elected in 1920. Out of his close association with such engineering and industrial matters as are indicated in the above details, has grown Mr. Crawford's deep interest in social economics from their humanitarian side, and especially in questions of hospital management and administration. He is a vice-president of the Homeopathic Hospital of Pittsburgh. He is also a member of the American Society of Mechanical Engineers (manager 1911-12), American Railway Engineering Association, American Association for the Advancement of Science, Franklin Institute, Illuminating Engineering Society, Association for the Promotion of Engineering Education, Engineers' Society of Western Pennsylvania, Fellow of the American Institute of Electrical Engineers, and member of the Academy of Science and Art, Pittsburgh, and the Scotch-Irish Society of Philadelphia. He is a member of the Metropolitan Club (Washington), the Engineers' Club (New York), The New York, Pittsburgh and Western Railway clubs, and the Duquesne, Athletic, Country, Oakmont, Traffic, and Automobile clubs, of Pittsburgh.

THOMAS DUNCAN

Thomas Duncan was born on December 26, 1865, on Drumrannie Farm, which borders on the town of Girvan in Ayrshire, Scotland. His birthplace is only a few miles from those of the poet Burns, and of King Robert the Bruce. The name Duncan, in this historical portion of Scotland known in ancient times as Carrick, is intimately associated with its development as far back as the tenth century. His father was civil engineer for the Marquis of Ailsa, and when Mr. Duncan was ten years of age, the family moved to Ireland, where his father was appointed as land steward to the Duke of Abercorn, Baronscourt, County Tyrone, and where the Duncans remained for seven years before returning again to the land of the heather.

Mr. Duncan received his education at the public schools of Girvan and Maybole, in Scotland; Letterbin National School, Baronscourt, and the Model School at Newtown-stewart in Ireland. While attending the Model School he showed a natural aptitude and liking for the study of electricity and magnetism, and led his class in this branch to the extent of being asked to assist in the experiments before his fellow students. Even before he was ten years of age he remembers the experiments he tried for himself, with two strips of coarse brown paper, which he heated and dried, then by rubbing one of them and not the other they would adhere tightly together; then by rubbing both they would repel each other. These experiments were again performed in a small dark closet underneath a stairway, which afforded an excellent opportunity to witness the miniature sparks that were drawn

THCMAS DUNCAN

from the excited strips of paper with the knuckle of one of the fingers; likewise, the electrical or phosphorent glow that was produced at the line of separation when the dissimilarly charged paper strips were quickly drawn apart. Still another of his early boyhood experiments was to rub together two pieces of loaf sugar until they glowed in the dark under the friction.

After leaving school the youthful experimenter took up pharmaceutical chemistry for a couple of years, but still being imbued with the idea of following an electrical profession, he decided to go to the United States where great possibilities were developing in all branches of that business, so in the fall of 1883 he came to the United States, and not finding anything in the electrical line to his liking he took up pharmacy. In the spring of 1886, at the continued solicitation of his parents, he returned home, his father offering to establish him in the drug business, but after a two months' vacation at the old stamping ground, he informed the folks at home that his love for America and its people was so great that no offer would induce him to remain, and in the fall of the same year he returned to Boston and, in the course of a short time, entered the employment of the Sun Electric Company, Woburn, Massachusetts. This company manufactured incandescent lamps, transformers and alternating current dynamos, so he had ample opportunity to take up these lines of work in a thorough manner. The following year he accepted a position with the Fort Wayne Jenney Electric Light Company, Fort Wayne, Indiana, in the manufacture of incandescent lamps. In the early part of 1890 he entered the meter department of the Thomson-Houston Electric Company, Lynn, Massachusetts, where he became thoroughly acquainted with the two meters that were on the market at that time. His principal work was the testing of meters for direct currents; also for alternating currents, and many tales can he relate with reference to the shortcomings of the meters of that period.

In December of the same year, Mr. Duncan returned to Fort Wayne, and took charge of the laboratory and meter-testing department of the Fort Wayne Electric Light Company. In 1893 he was granted several patents on meters, and in 1894 the Fort Wayne Company commenced to put the product of his inventions on the market, and for the eight years following, the Duncan meters found a large and ready market in every country where alternating currents were in use. In the latter part of 1898 he accepted a position as meter engineer for the Siemens & Halske Electric Company of America, Chicago, Illinois, and for whom he designed a full line of direct and alternating current watthour meters. These new instruments were becoming very popular and met with much favor among the central station fraternity, until 1900, when the General Electric Company purchased the Siemens & Halske plant.

In 1901 he organized the Duncan Electric Manufacturing Company and located at Lafayette, Indiana. His first product was direct current watthour meters only, but as the business expanded he added A. C. meters and transformers until, today, the plant, having grown from a modest affair employing a few people, and with a floor space of 15,000 square feet, now has a floor area of 200,000 square feet and employs nearly 500 people.

In 1909 a large four-story wing was added to the original building, then in 1912 the Company purchased the entire plant of the Sterling Telephone Company, situated across the street, thereby materially facilitating further expansion. Duncan meters are extensively used, not alone in the United States, but in Canada, West India Islands, Mexico, Brazil, Argentina, Bolivia, Uruguay, Chile, China, Japan, Siam, Spain, and Italy.

Mr. Duncan has been granted upwards of 200 patents on electricity meters and, in consequence, enjoys the reputation of being the most prolific and most successful inventor in his chosen art. His inventions cover the meter business in every detail, and a number of them are generic in character. Due to his ability as an engineer the meter business today has the following recognized improvements to its credit: The friction or light load compensating device for direct and alternating current watthour meters which provides adjustable means for maintaining the meter's light

load accuracy with increased friction due to age. This has proved to be one of the most valuable inventions in the art and is now used by all manufacturers of watthour meters in the United States and Europe. He was the first to introduce the magnetic shield in meters between the magnets and series field coils, so that the former would not be demagnetized through excessive magnetism from the latter when the meter was subjected to a short circuit. He also was the first to discover that by setting the permanent magnets, taken lengthwise, at a right angle to the magnetic axis of the series field coils, the weakening or demagnetizing effect upon the magnets is reduced to a minimum. He was the first to build an A. C. watthour meter model using an aluminum disk armature for both the motor and retarding elements—an arrangement now used by all manufacturers of these meters. Again, he was the first to disclose, by patent, the present day upper bearing in A. C. meters and which consists, essentially, of a spindle or shaft provided at its upper end with a recess, and a top bearing pin or needle stationarily mounted and projecting down into said recess. This arrangement is now extensively used, and marks a radical departure from the old practice of many years in which the bearing pin forms an integral part of the upper end of the spindle.

Mr. Duncan, while his parents were living, frequently visited the land of his birth. Upon one of these occasions in 1900, he and his mother visited the place where she was born. The house was a one-story stone and mortar structure with walls about two feet thick and situated on the seashore, with the public highway separating it from Denure Castle, the abode of the ancient kings of Carrick, and but a short distance from Tarnberry Castle, Bruce's birthplace. This little house where Mr. Duncan's mother was born was also the first abiding place of his grandparents after their marriage, and where his grandfather, Hugh Hannah, conducted a shop for the manufacture of wagons sold to the farmers in that vicinity.

Mr. Duncan is a member of the American Institute of Electrical Engineers, the Franklin Institute of Philadelphia, the American Electrochemical Society, and the American Association for the Advancement of Science. He is much interested in the development of his home town and is a director in several of the city's leading industrial corporations. He is a member of The Town and Gown, Lincoln, Lafayette, and Country Clubs.

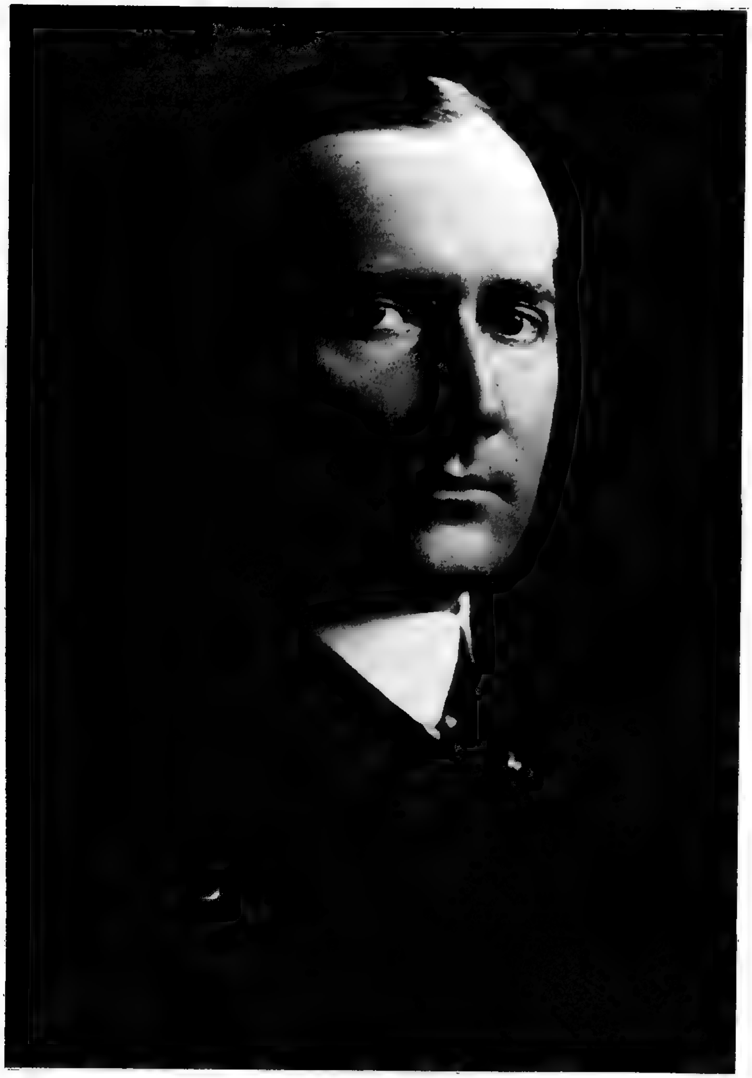
In recent years, Mr. Duncan spends his winters in California. His hobby seems to be having his garden and lawn around his home kept in immaculate condition; and he is an ardent student in geology and physics.

A. L. DRUM

Born at San Francisco, California, in 1875, A. L. Drum received his professional education at the Massachusetts Institute of Technology, from which noted seat of engineering study he graduated in 1896. He began active work forthwith, starting in the power station and on outside line and underground conduit and cable construction for the old Boston Electric Light Company. He then went with Stone & Webster, of Boston, as manager and constructing engineer of railway and lighting properties until 1900. He then became general manager and constructing engineer of the Indiana Union Traction Company of Indiana, operating 300 miles and constructing 190 miles of interurban and city trolley lines, until 1904; and during 1905 he was general manager and constructing engineer for the Chicago and Milwaukee Electric Railroad. Since 1906 he has been engaged in engineering business in Chicago as a consulting and construction engineer for electric railways.

He was a member of the Board of Supervising Engineers for Chicago Traction, representing the Calumet and South Chicago Railway Company from 1908 to 1913.

Among pieces of unusual work is that done as consulting and constructing engineer in charge of building a section of



A. L. DRUM

the Yonkers Pressure Tunnel, furnishing water supply to New York city; this tunnel being 17 feet in diameter and the section 2½ miles long. Mr. Drum's work as a construction engineer covers the construction complete of the following electric mileage: Indiana Union Traction, 165 miles; Mattoon Electric and Street Railway, 13 miles; Winona & Warsaw Railway, 5 miles; Logansport City Railway, 7 miles; Chicago & Milwaukee, 70; Jackson-Lansing Electric Railway, 38; Calumet & South Chicago Railway, 70; Chicago Consolidated Traction Company, 20; Hammond, Whiting & East Chicago Railway, 23; Chicago & Western Ry. Co., 5; Nezperce & Idaho Railway Company, 14 miles.

At the present time Mr. Drum is consulting engineer for the Twin City system of Minneapolis and St. Paul with 440 miles of track; Cincinnati Traction Company with 225 miles; Philadelphia Rapid Transit System with 670 miles; and the Dayton, Ohio, street railway properties, operating 108 miles.

Mr. Drum has also been engineer in charge of valuation on twenty traction systems aggregating about 2750 miles and valued at over $460,000,000, including the Chicago, Cincinnati, Minneapolis and St. Paul systems. A traffic survey and plans were made for the subway system of the Cincinnati Rapid Transit Commission, and in Philadelphia for extending the Market Street Subway-Elevated System to Frankfort by "L" and to Camden by tunnel under the Delaware. Mr. Drum also prepared plans for the Chicago surface lines and elevated roads for a down-town terminal subway system; and similar plans for underground plazas in connection with subway stations to relieve the traffic congestion at Herald and Times squares in New York city.

Another class of important work has been analyses of traffic congestions, that in 1914 in Philadelphia involving the rerouting of 2200 surface cars and increasing the capacity of the tracks in the business district by 51 per cent. Analogous work was done in Baltimore in 1917, increasing the capacity 41 per cent; and in similar studies for Cincinnati and Chicago.

During the Great War, A. L. Drum & Company served as consulting engineers on local passenger traffic for the U. S. Shipping Board, the U. S. Bureau of Industrial Housing and Transportation, and the U. S. Housing Corporation, under agreements by which the company gave the services of Mr. Drum without charge and those of its staff at cost only. For the Shipping Board, this including work on trolley service to 28 shipyards employing 70,100 men, and requiring 67,000 more men; at Hog Island the actual movement secured was that of over 15,000 employees in three-quarters of an hour; and the kindred work for the Housing Corporation dealt with street railway services for 460,000 men at 40 munition plants in 27 cities.

Mr. Drum was also a member of a committee of four appointed by the Housing Corporation to build a new city of 5000 houses at Neville Heights near Pittsburgh and planned to house the workers at the 18-inch gun plant on Neville Island in the Ohio River.

HARRY P. DAVIS

Mr. Davis was born at Somersworth, N. H., July 31st, 1868, was educated at the public schools of Worcester, Mass., and graduated from the Worcester Polytechnic Institute in 1890, returning the following year to take a post-graduate course in electrical engineering. A very definite bent for mechanical things and the interest aroused in the late eighties by the various applications of electricity then being undertaken, invited the attention of the young engineer, who had a keen appreciation of the very large field thus opening up.

He began his professional career with the old Thomson-Houston Electric Company, as a student in its works at Lynn, Mass., but left them after a few months to affiliate himself with the engineering organization of the Westinghouse Electric & Manufacturing Company at Pittsburgh, Pennsylvania. He very early visualized

the great future in the detail work in electrical manufacturing, and was appointed to organize and develop what was known as the Detail Engineering Department of the Westinghouse Electric & Manufacturing Company. His aptitude in engineering, coupled with his pronounced inventive and executive ability, naturally led to more or less rapid advancement, and he was appointed Assistant Chief Engineer August 1st, 1904; Manager of Engineering, April 15th, 1909; Assistant to First Vice-President, January 29th, 1910, and on August 1st, 1911, was elected Vice-President in charge of manufacturing and engineering—a position which he still holds.

In the transportation field, Mr. Davis had direct supervision of the development, design and actual installation of the great plant involved in the electrical equipment and electrification of the lines of the New York, New Haven & Hartford Railroad. Similar work was done on the electrification of the Hoosac Tunnel and the St. Clair Tunnel, as well as the Pennsylvania Railroad Terminal. These were among the first big projects on electrification successfully introduced in this country, which have resulted in the further and more complete electrification of other great railway systems, tunnels and terminals.

The great advances in traction and transportation due to this application of electricity to the waiting field of steam locomotion, and the gradual supersession of the old by the new motive power, have not only necessitated but have witnessed a great many inventions which have formed an important factor in the new art growing up around the swift transition of main line railroads from steam to electricity as the propelling energy. In all this newer field of electrical application, Mr. Davis has been a notable and creative leader, and has contributed to the electrical arts a great many important inventions and improvements in equipment and apparatus necessary for this development.

To such devices as switches and insulators, Mr. Davis has applied the same engineering skill and painstaking care that are bestowed on the larger and more complicated apparatus. He has taken out nearly a hundred patents, mostly covering resistance coils, circuit breakers, controllers, fuse blocks, solenoid brakes, wattmeters, railroad line current collecting apparatus, arc lamps, trolley clamps, etc. His arc lamp set a standard in the days when this form of illumination was dominant, and his alternating current meter superseded the original Shallenberger type.

Early in his engineering administration he visualized the necessity of developing new types in motors, generators, transformers and their combinations with prime-movers, and showed an insight into matters of the most intricate technical nature which betrayed a most rare gift of engineering intuition.

This is a very bare outline, however, of his close relationship with a great deal of the development and achievement of the past twenty-five years in the important field of electrical development.

It has not been, however, as a competent designing and inventive engineer that Mr. Davis has entirely done his best work in electrical engineering lines, but he has also achieved prominence as a manufacturing executive, and his duties today embrace the whole range of engineering, production and application over which the great Westinghouse organization exerts its powers. He has the reputation of getting results regardless of obstacles, and further has a peculiar genius of recognizing the needs of industry and providing by far-sighted policies for the necessary changes in adapting a large manufacturing organization to the new conditions arising from a complete change in the evolution of industry.

Mr. Davis is a member of the American Institute of Electrical Engineers, Engineers' Society of Western Pennsylvania, the University Clubs of New York and Pittsburgh, the Engineers' Club of New York, Pittsburgh Athletic Association, and the Oakmont and Edgewood (Pennsylvania) Country Clubs. He is also a member of the Pittsburgh Chamber of Commerce, Pittsburgh Board of Trade, and has been since its organization a Director of the Employers' Association of Pittsburgh. His residence is in Pittsburgh, Pa.

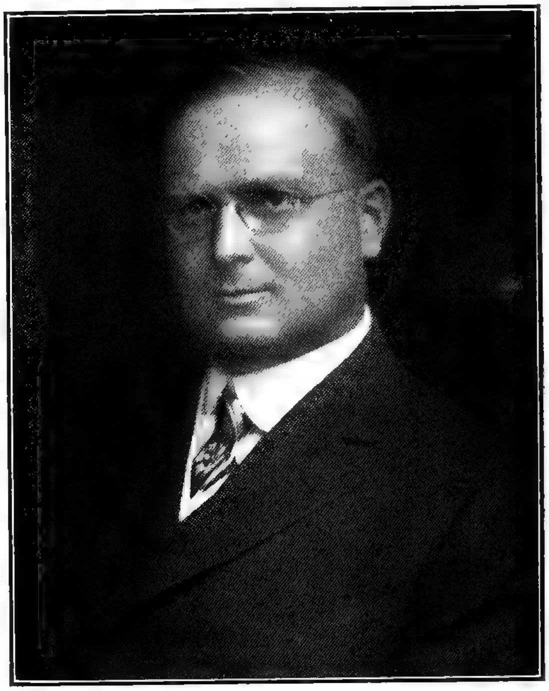
HARRY P. DAVIS

EDWARD PAUL DILLON

As general manager of the Research Corporation, New York, E. P. Dillon has executive supervision over the application to industry of the Cottrell processes of electrical precipitation. Technical work of such highly specialized nature presupposes a directing hand of commensurate experience. Mr. Dillon's career began with the Cochiti Gold Mining Company of New Mexico, progressed through successive managerial positions with the Telluride Power Company, Colorado Springs Electric Company, Pikes Peak Hydro Electric Company, Westinghouse Electric & Manufacturing Company, and finally brought him to New York as manager of Power Division of the New York office of the Westinghouse Company, from whence he came to his present duties.

Mr. Dillon was born at Denver, Colorado, May 17th, 1877. His academic preparation in electrical engineering was obtained at the University of Colorado, where he pursued engineering courses culminating in the degree of B.S., taken in 1899.

Widely known in the electrical profession at large, Mr. Dillon is a member of the American Institute of Electrical Engineers, and the National Electric Light Association. He presented papers before the latter body in conventions at Denver in 1895, and Chicago in 1913.



EDWARD P. DILLON

LOUIS C. EITZEN

In telling of the work of Louis C. Eitzen, the record must be regarded as being far short of complete. He is just beginning now, although he has already gone far beyond the point at which many stop, and has laid foundations which should assure him a future of useful achievement.

Mr. Eitzen is a distinct type, being an unusual blend of the scientific bent with the orderly talents of the business man. He has assiduously accumulated stores of knowledge in several fields, each complementary to the other, and as a whole forming a possession won only by the utmost perseverance and devotion to ideals. Naturally, his success has been called "meteoric," as apparently sudden success is often termed, but it was rather the result of far-sighted planning and good generalship backed by hard work.

Louis C. Eitzen was born in Hoboken, N. J., August 9th, 1886. Love of things scientific ripened into prospects for exclusive study in one of the country's great schools of technology. This intention being defeated by contrary circumstances, the youth became instead an apprentice with the Lambert-Schmidt Telephone Company at Weehawken, N. J., where he finished a short period of labor and observation in the position of assistant to the chief engineer. Every succeeding step of his career was taken for a deliberate purpose, and frequently at the sacrifice

of lucrative and seemingly important positions. In 1903 he might have selected a post in some manufacturing plant. There, however, the opportunities for gaining increased knowledge would doubtless have been circumscribed by the stereotyped nature of processes. At the shops of the James Reilly Repair & Supply Company, of New York, on the contrary, he spent profitable time in the repair department, repairing motors, generators, etc., and assisting in the preparation of estimates on electrical work.

Professor W. H. Bristol, of Stevens Institute, induced Mr. Eitzen to join him in the development and manufacture of electrical pyrometers, and he was given charge of the manufacturing and calibrating departments of the Wm. H. Bristol Pyrometer Company, of which Professor Bristol was president. The business enjoyed mounting prosperity, culminating after three years in a consolidation with the Bristol Company of Waterbury, Conn., and the removal of the plant from New York to Waterbury. Mr. Eitzen did not follow, though there were ample rewards to tempt him. He had begun a course in electrical engineering at Cooper Union, New York, in 1905, and did not propose to let anything interfere with its completion. So, while passing the evenings in study, he continued in day time employment at the Electrical Testing Laboratories, of New York, there dealing with numerous and intricate tests of electrical apparatus—an enlightening pursuit when taken in conjunction with the theoretical exposition of the class room. His resignation coincided with the winning of the B. E. E. degree at Cooper Union.

One of Mr. Eitzen's strong beliefs is that the practising industrial engineer should be conversant with business organization and its cognate elements, the neglect of which has set at naught the calculations of many an engineer. True to his convictions, he studied law, accounting, and business administration at Pace Institute, New York, graduating in 1916. While thus engaged, he began a five-year connection with the Standard Underground Cable Company, of Pittsburgh, as sales and electrical engineer in their New York offices, gaining valuable experience on the commercial side of engineering and contributing abilities in organization whose worth was recognized by the higher executive officers.

When he became general manager of the August Mietz Corporation, manufacturers of stationary and marine oil engines, in 1917, Mr. Eitzen faced a condition necessitating the introduction of a general and cost accounting system and a complete reorganization of the financial, commercial and productive functions of the corporation.

All this he accomplished and more before resigning in May 1919. Since that time in addition to a large amount of other constructive work he successfully carried through the development of an ambitious program for the Pittsburgh Filter & Engineering Company which had a clear purpose in view and exercised discriminating selection when appointing Mr. Eitzen as Vice President of the Company and General Sales Manager of its oil engine division with headquarters in New York. It was his task to coordinate the elements of the company's manufacture and distribution of oil engines according to the approved principles of modern scientific management. He is now engaged on a similar program for the Elsee Products Corporation of New York and also upon a constructive program of the Louis C. Eitzen Organization with headquarters at 280 Broadway, New York, through which he is acting as resident New York executive for a number of American manufacturers.

Had the war not ended when it did, Mr. Eitzen would have assumed a position of responsibility in the Government Ordnance Department. Negotiations for his services were interrupted by the armistice. Mr. Eitzen is a member of the American Institute of Electrical Engineers, the American Society of Testing Materials, and the Export Managers Club, of New York, besides several rowing and boating clubs, the latter fact indicating his hobby in the matter of sports.

LOUIS C. EITZEN

JOHN W. ESTERLINE

JOHN W. ESTERLINE

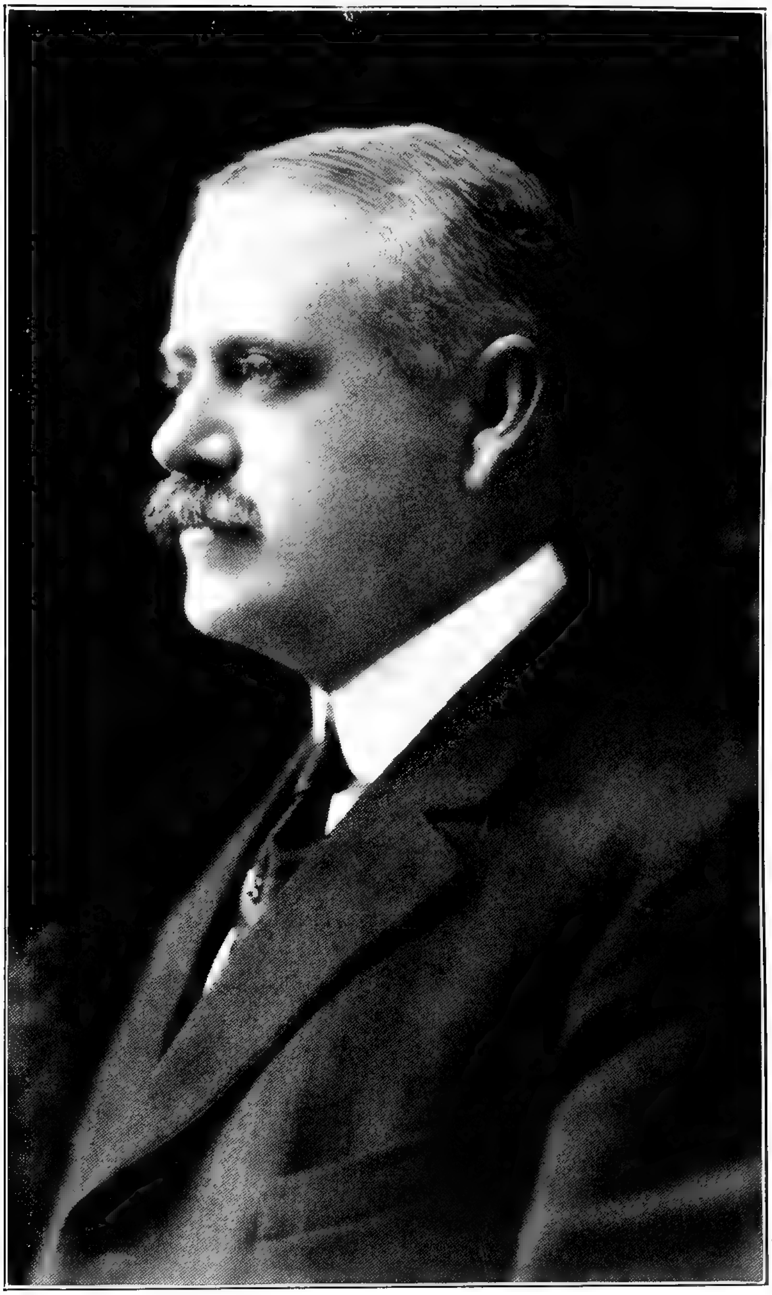
Like several other well-known men in the electrical field—such as Henry C. Doherty and Frank W. Frueauff—it was as a newspaper boy that John W. Esterline began active life. He was born near Fort Wayne, Ind., where his father was a mechanic and proprietor of a carriage shop; in the days when vehicles were still made by hand. The eldest of nine children, John W., practically left home when he was only 14; and by carrying daily papers he worked his way through Fort Wayne College, finishing there in 1893. At that time his fighting weight even with clothes on was only 79 pounds—but in addition to school and newspaper duties he put in an hour daily at the Y. M. C. A. gymnasium. When he entered Purdue University in September, 1893, he had already doubled his weight. Helped a bit by his parents, he worked his way through Purdue, with special study of electrical engineering, graduating with high honors in June, 1897. Not only was he a member of the Sigma Nu and the Tau Beta Pi, but he played fullback on a championship football team, ran on the track, and was president of the Athletic Association.

The year following graduation Mr. Esterline was engaged by the University as graduate manager of athletics and as an assistant in the electrical laboratory. In rapid succession he became instructor, assistant professor, and professor of electrical engineering; and in eight years he was acting as head of the electrical department. In 1907, however, he resigned from the University to afford play to his inherited mechanical ability, and gave all his time to The Esterline Company of Lafayette, Ind., which had started several years previously in a barn with one employee and a 1/3 hp. motor driving a small lathe. The company began with general designing of special testing and experimental apparatus, but gradually narrowed its lines until in 1913 it was doing a business of about $1,000,000 in graphic instruments, automobile lighting and starting equipments and permanent magnets. In March of that year the plant was almost entirely wiped out by the terrible floods that devastated the North Central States. With characteristic energy Mr. Esterline moved what was left of his equipment to Indianapolis, began all over again, dropped the manufacture of automobile equipment, and concentrated on the graphic instruments in which he is recognized as a pioneer. Of these his company now manufactures the widest range, enjoying an enviable reputation for quality and accuracy.

Mr. Esterline has also built up a fine consulting practice continued by the firm of Esterline & Angus, engineers, which also manages a number of industrial properties. He is a typical representative of the modern educator who has fortified his teaching skill by direct contact with the industrial life of his time, and who vice-versa has brought to the commercial field elements that only the seats of learning can supply.

Mr. Esterline is, of course, a member of the American Institute of Electrical Engineers; and also belongs to the Indianapolis Athletic Club; the Indianapolis Rotary Club; and other organizations. He is a scholarly man of wide reading, and artistic tastes; a good writer, and a fluent speaker. His keen interest in young men has led him to help many organizations aiming to develop youthful character and ambition to do worthy things. His hobbies are fishing and pastel drawing, and on the walls of his home are many beautiful crayons of his own drawing. He thus reminds one of the late Sylvanus P. Thompson of England. He is a leading American authority on permanent magnets, and author of "The Design of Electrical Machinery." His fame will doubtless rest on his mastery and leadership in the field of graphic instruments and their use which has been so beneficial in the arts.

LOUIS A. FERGUSON



One of the outstanding figures in this generation of electrical men is Mr. Louis A. Ferguson, vice-president of the Commonwealth Edison Company of Chicago, in charge of contract, construction and electrical departments. Mr. Ferguson was born at Dorchester, Massachusetts, in 1867, graduating from the electrical engineering department of the Massachusetts Institute of Technology in 1888, entering the employ of the Chicago Edison Company the same year; thus his business career has been identified solely with this company. Mr. Ferguson combines that rare quality of hard commercial instinct with a genial and pleasing personality that has made him the ideal leader among men of his profession.

He was president of the National Electric Light Association 1902-3; the Association of Edison Illuminating Companies 1901-3, and of the American Institute of Electrical Engineers 1908-9. He has also served as president of the Northwestern Alumni Association of his alma mater. He is a member of the Engineers' Club of Chicago; of the Chicago Athletic; Commercial; Midday; University; Glen View, and Old Elm clubs. His home is in the beautiful suburb of Evanston, Ill., and his office with the Commonwealth-Edison Co., at 72 W. Adams Street, Chicago.

Mr. Ferguson has contributed much to electrical literature and he has been a pioneer in using many features of generating and transmission of electricity in conjunction with central and substation work.

HENRY WRIGHT FISHER

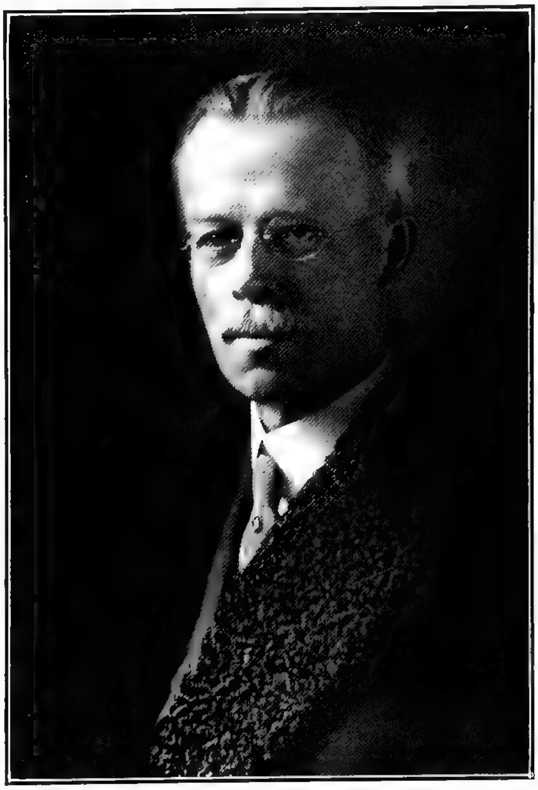
Henry W. Fisher, chief electrical engineer and manager of the Lead Cable and Rubber Works of the Standard Underground Cable Company, of Perth Amboy, N. J., was born in Youghal, Ireland, January 31, 1861, the son of Abram and Sarah (Wright) Fisher.

Mr. Fisher's family tree shows that his father was a direct descendant of Reuben Fisher, who was a merchant in London and who went to Ireland about 1680 to visit a married sister where he took up his residence, joining the Society of Friends of which his sister was a Member. Mr. Fisher was born a Member of this religious Society.

Mr. Fisher's mother was a direct descendant of the Dudley family, a notable ancestor of hers being Lord Northumberland of the time of King Henry VIII of England. When Prince William (afterwards King William IV of England) was at Cork, he resided at the home of Mr. Fisher's great grandfather.

One of Mr. Fisher's ancestors fought with the English at the battle of Bunker Hill where he became convinced that America was right and at a considerable expense he was released from war duty so that he would not have to fight in what he considered an unjust cause.

Mr. Fisher came to America in 1874 and fourteen years later received the M.E. degree of Cornell University. After graduation he was connected with Bergman & Co., and the C. & C. Motor Company and then entered the service of the Standard Underground Cable Company, becoming its chief electrical engineer in November, 1889. He devoted part of his time to developing the testing department of the Central District & Printing Telegraph Company of Pittsburgh, from 1891 until 1893, and was later superintendent of the Pittsburgh factory of the Standard Underground Cable Company.



HENRY W. FISHER

Mr. Fisher is a member of the American Institute of Electrical Engineers, the Engineers' Society of Western Pennsylvania, of which he was president in 1901-2, the American Electro-Chemical Society,

American Society for Testing Material, Sigma Xi Fraternity, University Club of Pittsburgh, the Chemist's and the Cornell University Clubs of New York, East Jersey Club of Perth Amboy, and is ex-president of the Esperanto Association of North America.

Mrs. Harriet W. Fisher, his wife, is a direct descendant of Elliott, the Apostle to the Indians, and also has her qualification papers so that she is eligible to the Colonial Dames and Daughters of the American Revolution.

Mr. Fisher has devoted much time to research and investigation and has originated methods of locating faults in cables, etc. He has prepared many papers as the result of this work which he has read before the electrical bodies and contributed to the technical press.

FRANK W. FUNK

It is in America no less than in Europe that one sees curious and notable blending of lines of ancestry, as exemplified once more in the fact that Mr. Frank W. Funk is descended from John Rogers, a Scotch martyr who gave his life at the stake for his religious convictions, and is also through his ancestors indirectly related to old John Quincy Adams, who would just as willingly have died in the flames rather than give up any political belief. Mr. Funk was born November 25, 1886, at Scottdale, Pa., and as a boy lived so near the Westinghouse Works at East Pittsburgh, that the very air had an electrical inspiration; and it "went to his head" in determining his career. He graduated from the Ohio State University in electrical engineering in 1908 and was president of the Student Section of the A.I.E.E.; his college fraternity being Eta Kappa Nu. He began his career in 1908 with the West Penn Railway Company at Connellsville, Pa., doing general work in the construction department for a short time; and his subsequent connections have been engineer on switchboard equipment development, with the Westinghouse Electric & Manufacturing Company; assistant electrical engineer and assistant superintendent of motive power for the Northern Ohio Traction & Light Company; electrical engineer for the Mahoning & Shenango Railway & Light Company, now the Penna. & Ohio Electric Co.; electrical engineer and district engineer for the Republic Railway & Light Company, and the Republic Engineers, Inc., and as one of the members of the firm of Crippen & Funk, electrical, mechanical and industrial engineers.

As one of the Westinghouse engineers, Mr. Funk had to do with switchboard research development and equipment; but his later experience included the design, construction, operation and maintenance of power plants, substations, transmission systems, overhead and underground distribution, street lighting, railway construction, and later power analyses and reports, appraisals, industrial plant design, power application to industries, and illumination in its varied problems.

One of the features of the present engineering age has been the creation and development of engineering bodies, branches of the great societies or distinct and useful local territorial organizations; doing a great deal of needed and useful work in upbuilding the engineering profession and status. Mr. Funk was during 1918 and 1919 president of the flourishing Engineers' Club of the Youngstown district, a rapidly growing organization which already has a membership of no fewer than 650 experts—mechanical engineers, electrical, civil, chemical, metallurgical, architectural, and all the other diversified groups into which engineering now falls in practice, and all of which the great modern engineering arts hold together in harmonious fellowship. Mr. Funk is also a member of the American Institute of Electrical Engineers, member of the American Electric Railway Association, and an Associate Member of the Iron and Steel Electrical Engineers. His broadness of

FRANK W. FUNK

sympathies has enabled him to go far in massing the professional engineering forces of the great productive territory of which Youngstown is the heart and center. His home is at 215 Woodbine Avenue, Warren, Ohio.

FRANK FULLER FOWLE

Frank Fuller Fowle, engineer and executive, was born at San Francisco in 1877 and graduated from the Massachusetts Institute of Technology in 1899. His

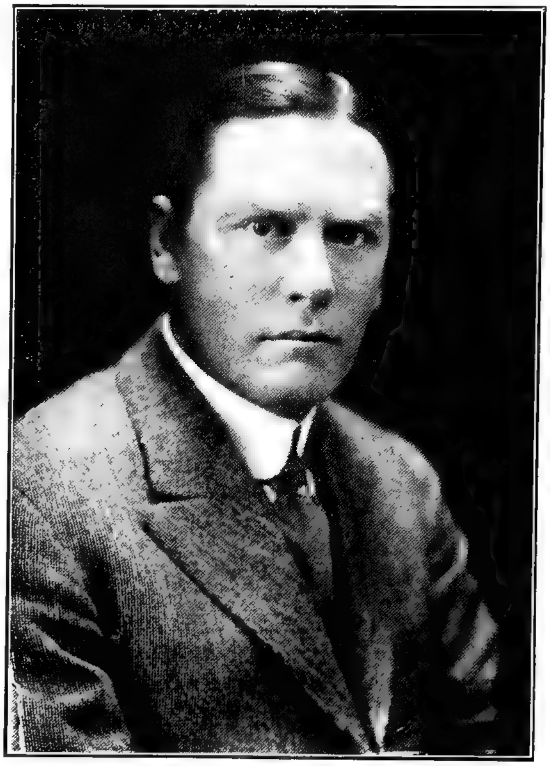
FRANK F. FOWLE

start in practical life then began with the American Telephone and Telegraph Company, in whose service he remained for the next nine years, distinguishing himself especially for original work in connection with inductive interference between power and telephone systems, and in extending the application of telephone communication on trunk line railroads. From 1908 to 1912 he was in general practice as a consulting engineer at Chicago, leaving this field for a year to serve as Associate Editor of the "Electrical World," but returning to consulting work again in 1913.

His breadth as an electrical engineer was evidenced by his appointment that year by the McGraw-Hill Book Company as Editor-in-Chief of the "Standard Handbook for Electrical Engineers," the fourth edition of which, completely re-written and revised, appeared in 1915. In 1914 he was appointed one of the receivers of the Central Union Telephone Company, serving for five years as one of the chief executive and operating officials of this large system. At the conclusion of the receivership he returned again to the consulting field. Mr. Fowle is also known for his original work on the properties of iron, steel and copper conductors, including copper clad steel. His work in the consulting field has covered a wide range of electrical engineering and public utility rate cases and economics. He is the author of numerous professional papers and has held many prominent offices in engineering societies. Withal he has found time for active interest in civic affairs and a hobby on prints and interesting books.

WILLIAM L. GOODWIN

Very few plans of coöperative working are so well known as what is styled throughout the electrical field as the "Goodwin Plan," from the fact that its advocacy and propaganda are so closely associated in the public mind with its author, Mr. William L. Goodwin. In all its carefully studied "planks" and details this fundamental scheme for the harmonious coöperation of a great industry, the plan would require much more space than can be here allotted to it—besides which it is now so well known that neither its originator nor its principles at this late date need any very elaborate description to the electrical public. The plan is based essentially on a campaign of education, carried on through trade journals, trade bodies, allied engineering organizations and all the other correlated agencies, for a proper functioning of each element in the great electrical field within its own legitimate sphere of action, so as to secure the best electrical service to the American public through agencies that effect a more favorable public opinion, a larger per capita consumption of electrical energy, apparatus, service, devices and supplies, with greater efficiency in their distribution, through established retail distribution to the consumer at fair prices, and at a fair profit to all parties taking a part in the transaction—thus linking together progressively all groups and classes—manufacturers, central stations, jobbers, contractor dealers, supply houses, etc. Here is a platform broad enough for all electrical men to stand and work on; and to



WILLIAM L. GOODWIN

carry it out to useful practice takes in a wide range of feasible propositions to all of which Mr. Goodwin has devoted his

time and energy and thought, and no small measure of organizing and oratorical ability.

Mr. Goodwin, who was born at San Francisco, Cal., July 24, 1876, completed electrical courses at the Van de Vaillen School of Engineering, while working nights in the City Department of Electricity. He passed an examination for department superintendent with the extraordinarily high grade of 98.6 per cent., probably unequaled. From 1901 to 1905 he carried the responsibilities of the large San Francisco office of the Western Electric Company, and resigned in 1905 to establish himself in the jobbing business. He had just got under full headway when the great fire of April 18, 1906, wiped him out with heavy loss and indebtedness. By hard work he pulled through and in 1909 consolidated his own and kindred concerns to form the Pacific States Electric Company of San Francisco, with branches at Oakland and Los Angeles, reaching out later to Portland and Seattle. An organizer and leader by nature he had as early as 1900 organized the fruit growers of California, and in 1915 became interested in organizing the motion picture industry —himself owning four "movie" theatres in 'Frisco. In 1916, after eighteen years as an electrical jobber, he resigned as vice president and general manager of the Pacific States Company, then doing a $4,000,000 business annually, bought a big farm and planned to settle down as an agriculturist and movie magnate. An invitation to go East in January, 1917, to expound his coöperative ideas, and try them out on the whole industry, led to the formulation of a most notable campaign, based on the Goodwin Plan, and still being carried on with growing recognition and cumulative effect.

GEORGE H. HARRIES

General George Herbert Harries has had a career not less varied than his talents are diversified. He was born in Haverfordwest, South Wales, England, in 1860. Coming early in life to the United States—by way of the Canadian Northwest—and taking up journalism as a profession, he saw fighting while still quite young, serving in Indian warfare on the frontier under Generals Crook and Miles, and acting as a military correspondent for Eastern newspapers. Later his activities as a member of the Sioux Indian Commission were notably successful.

A student in all that touched upon the possibilities of electricity as an economic motive force, he, while successively reporter and editorial writer on the "Evening Star" of Washington, D. C., became familiar with and interested in the problems of public utilities; and when only thirty-five was elected President of the Metropolitan Railroad system of Washington. Later on, as a member of the Board of Directors and Vice-President of the Washington Traction and Electric Company, he participated actively in the consolidation of the electric light, power, and nearly all of the traction properties of the National Capital. He was the vice-president of the succeeding corporation—the present Washington Railway & Electric Company —until October, 1911, when he resigned to become associated with H. M. Byllesby & Co., of Chicago, large owners and operators of public utilities, as vice-president; and as president handled with success the affairs of both the Louisville, Ky., Gas & Electric Company, and the Omaha, Neb., Electric Light & Power Company; besides assisting down to date in the general administration and operation of other Byllesby properties. His work naturally attracted attention throughout the public utility field and his commanding ability and knowledge of politics and social economics led to his election as president of such important public utility organizations as the American Electric Railway Association and the Association of Edison Illuminating Companies, to both of which in turn he rendered distinguished service.

Throughout all this, General Harries retained his interest in military matters, and in the Spanish-American War commanded a regiment of Infantry at the siege

GEORGE H. HARRIES

of Santiago de Cuba and in the Cuban Army of Occupation. He then became Brigadier-General in command of the forces of the District of Columbia, which latter position he held up to the date of his voluntary retirement in 1915, by which time he had been appointed to the rank of Major-General. When the United States entered the Great War he was at once called upon for even more active service to his adopted country; at first in the training of troops at home. He was soon in the thick of things, however, in France, all the way from Verdun to Brest. At the latter place he was in command and there he planned and directed the construction and operation of the great base through which vast stores of supplies and more than fifty per cent of the American Expeditionary Forces entered France. For these services he was awarded the Distinguished Service Medal of the Army and was made a Commander of the Legion of Honor of France.

On the signing of the Armistice he was at once sent by General Pershing to Berlin as the American member of the Inter-Allied Commission on the Repatriation of Prisoners of War, being the first American officer to enter the city of the Kaiser after the conclusion of active hostilities. As a member of the Inter-Allied Commission and as Chief of the United States Military Mission he gave some nine months to this arduous work, doing inestimable good in caring for and returning to their homes literally hundreds of thousands of captives of all nationalities. For this service he has received already many European decorations. On his return home, however, he resumed civilian duties with wonted energy—as Vice-President of H. M. Byllesby & Company—and has again enjoyed recognition in the engineering field, having been elected President of the Illuminating Engineering Society of America.

General Harries has, however, received other recognition than that of foreign governments and his own and of the above-named Societies. He is Commander-in-Chief of the Military Order of the World ar, the organization of officers who rendered faithful service. He has been National Commander of the Order of Indian Wars of the United States, President of the Society of American Officers, Vice-President of the National Rifle Association, Department Commander of the Spanish War Veterans, and President of the Washington, D. C., Board of Trade. His interest in educational matters is testified to by his membership in the Washington, D. C., Board of Education, of which for many years he was Vice-President, and by his prolonged activities in the War Department Board on the Promotion of Rifle Practice. The State University of Kentucky conferred upon him the honorary degree of Doctor of Laws, while Howard University of Washington recognized his services as a lecturer on colonial history by the degree of Master of Arts. With unusual command of forceful eloquence, General Harries has long been in demand as a public speaker on utility problems and military and international topics, the latter especially since his unique experiences in France, Belgium, Berlin, and in Eastern and Southern Europe under the most varied conditions.

GEORGE A. HUGHES

One of the electrical appliances which will in the near future become as widely used as the electric vacuum sweeper or the electric iron, is the electric range. The man responsible for this is George A. Hughes, now president of the Edison Electric Appliance Company. He had an idea and refused to give it up in spite of the oft-repeated assertion by electrical engineers that his idea was impractical and impossible.

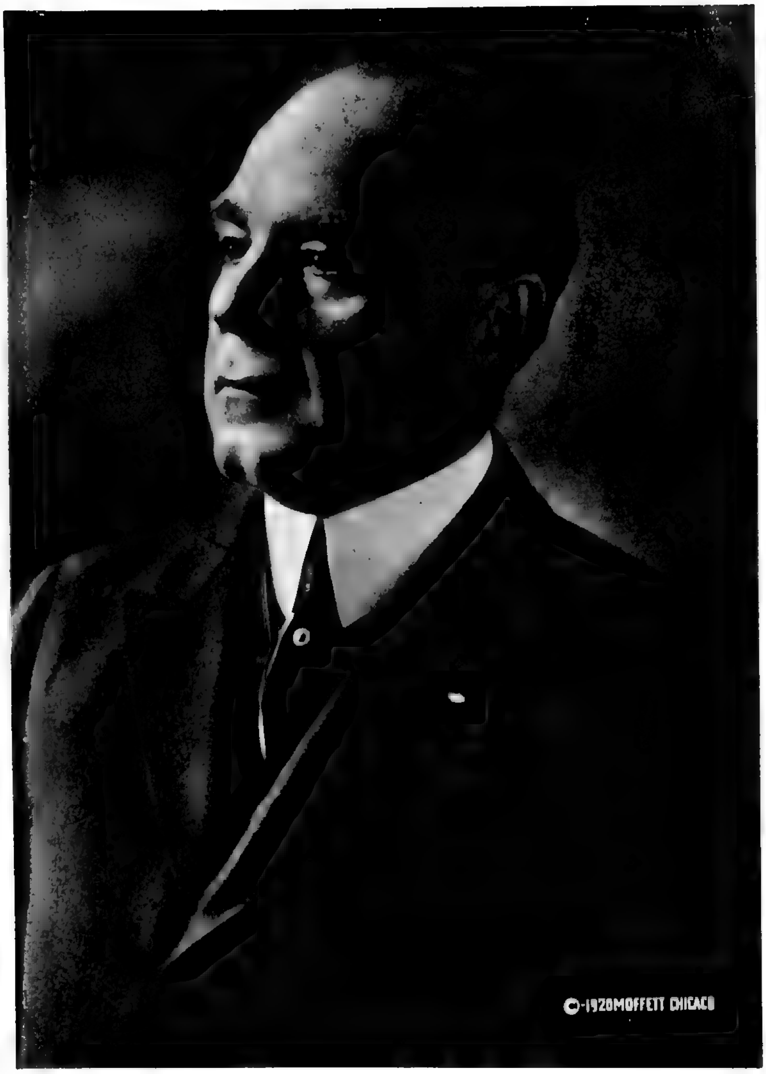
George A. Hughes was the son of a lawyer, but apparently the legal profession did not appeal to the lad, who started his business career as a cub reporter on the daily newspapers in St. Paul and Minneapolis. He was sent to Fargo as a representative of the St. Paul *Dispatch.* That one move probably lost the newspaper business a real editor, but it gave the electrical industry a man with a vision and the bull-dog ability to stick with a thing he believed was possible until he had accomplished it. At the time he went to Fargo that city was suffering from an overdose of a public service corporation that ran on the policy of "the public be damned." What service there was, was bad, and the rate was thirty cents per kilowatt hour. Sensing a business responsibility, the young reporter went before the city council and asked for a competitive franchise. Needless to say he got it, and with the aid of his father, Alexander Hughes, who for some years had been legal representative of the Northern Pacific Railroad in North Dakota, succeeded in interesting some business men in the proposition. The plant was built, real service and fair rate for electricity were given, and the other plant, inefficiently managed, was, as it should have been, forced out of business.

Having met with success in this venture, George Hughes started a company to build municipal electric light plants and operate them under a franchise. Several of these plants were installed in Montana and the Dakotas. In the back of his head was the idea that an electric range could be built that would be satisfactory. Some small electrical appliances, not requiring a heat greater than 600 degrees Fahrenheit, were being put on the market at this time, and Hughes was continually experimenting to see if it were not possible to find a metal which could be made into units to stand a higher temperature. Several different metals and alloys were tried out, and in 1910 at an electrical exposition in St. Louis he exhibited an electric range, made from an oil stove, with an open unit which appeared to have the required properties.

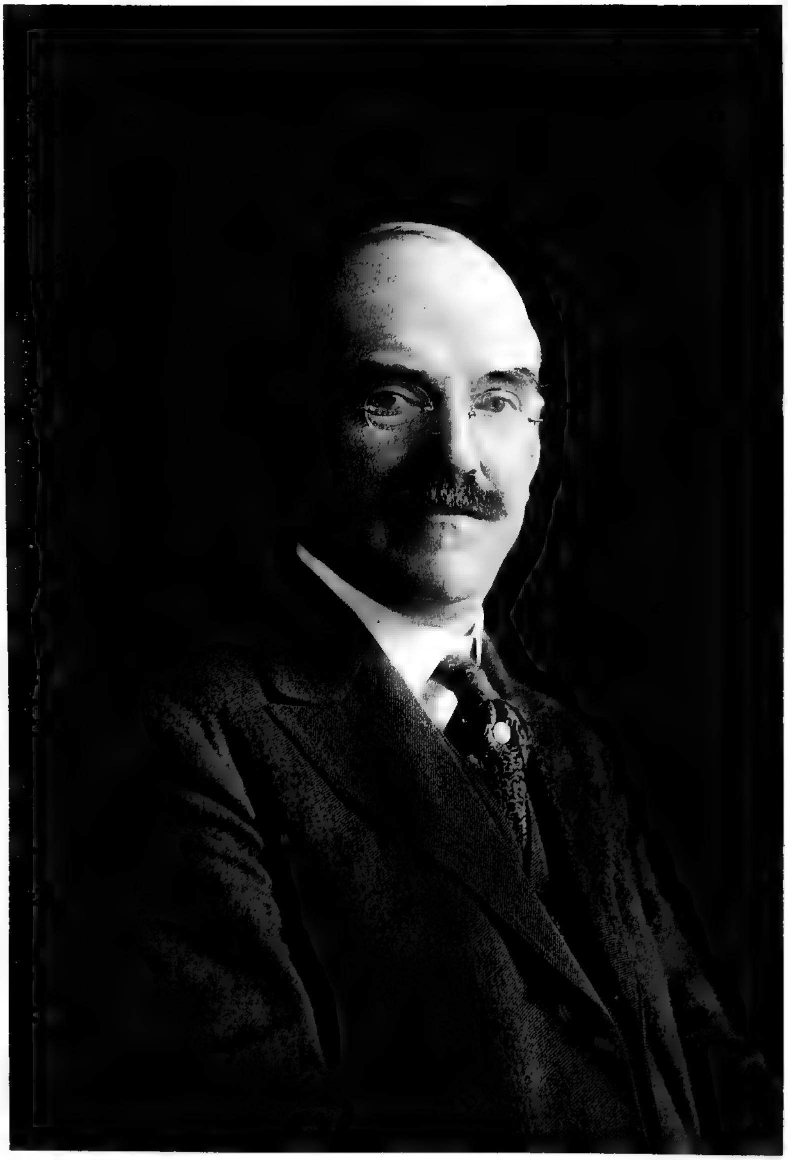
Through the trials and tribulations of an inventor seeking financial assistance Mr. Hughes kept busy trying to find still more satisfactory metals to use in the construction of the units on the range. After the exhibition of his crude range at St. Louis Mr. Hughes returned to Chicago, where he had made his headquarters, and began to turn out ranges. The question of finances was always troublesome, and sometimes it looked as if the plant would have to be shut down on account of the lack of supplies. But about that time a check would come through for some ranges, more supplies would be bought, and the work would again go forward. Improvements were made from time to time, and soon the ideal metal of which George Hughes had dreamed so often, made its appearance in the form of an alloy of nickel and chromium, which had been discovered by an American engineer, who had been looking for a suitable metallic compound for automobile bearings.

Since the time that crude affair which was the first electric range was put on exhibition in St. Louis, the electric range has passed the experimental stage and is now in the front line of those electrical labor-saving devices which are making the home life of the American woman more congenial. That it is practical is shown by the fact that there are many apartment houses which are entirely equipped with electric ranges, besides the thousands of homes throughout the country which are so equipped. The future of the electric range is assured, as is the comfort of the American housewife.

From the Journal of Electricity and Western Industry.



GEORGE A. HUGHES



FRED S HUNTING

FRED S. HUNTING

Pioneers often stray away from the scenes of their early achievements, and the environment that knows them no more may itself pass away, but in the story of Mr. Fred S. Hunting at Fort Wayne, Ind., we have the pleasant picture of a man still busy on the old "stamping ground" where a notable record has been made of which he is an inseparable "past and present." Graduating in 1888 from the Worcester, Mass., Polytechnic Institute, where he received a $75 cash prize as one of the first six men in the class, who had written a thesis on "Transformers," or converters as then called; and this led at once to his being employed by Mr. Robb Mackie, of the Fort Wayne "Jenney" Electric Light Company as assistant to M. M. M. Slattery, famous as one of the fathers of the alternating current system in America, and who was then developing at Fort Wayne, Ind., its commercial possibilities. With a modest beginning in the drafting department, Mr. Hunting soon became an assistant to Slattery in engineering work, in charge of detail design and testing. To this was added work on the old Jenney arc lighting system, and later when Mr. Charles S. Bradley, a pioneer in the A. C. multiphase field, began at Fort Wayne the development of his multiphase generators and motors, Mr. Hunting was assigned to assist him. While so engaged Mr. Hunting made some important inventions of his own, and his patents on the system or devices in reality antedated the well-known patent of Prof. C. F. Scott on a transformer to convert from two to three phases, or vice versa, familiar in the art as the "Scott" connection.

Nor was this all. When Mr. James J. Wood, of arc lighting fame, went to Fort Wayne in 1890—that buzzing center of invention and production founded by the late R. T. McDonald—once more Hunting got his opportunity, and became closely associated in the design, testing, etc., of the celebrated Wood arc lighting and D. C. and A. C. incandescent lighting systems.

In the Fall of 1893, Mr. Hunting took up commercial engineering work and became chief engineer of the engineering department at Fort Wayne, which had charge of designing, estimating and building central station plants throughout the U. S. A. With the organization of the Fort Wayne Electric Works in May, 1899, Mr. Hunting was made sales manager and treasurer in general executive charge of the company's business. The merger with the General Electric Company came in June, 1911, and with the turn of the wheel Mr. Hunting found himself general manager of what became again in March, 1915, the Fort Wayne Works, rather than a simple department of the General Electric Company. Since that time he has been general manager of the Fort Wayne Works and manager Fort Wayne Department—the Commercial Department of the "G. E." handling certain of the Fort Wayne products.

Nor does this quite cover all the activities of a strenuous life, for Mr. Hunting is vice-president and director of the Electric Vacuum Cleaner Co. of Cleveland; vice-president and director of the Tri-State Loan & Trust Company of Fort Wayne, a director of the First and Hamilton National Bank, a director of the Wayne Knitting Mills and of the Lincoln National Life Insurance Company; he was a member of the Allen County Council of Defence during the war, and was the first president of the Chamber of Commerce of the city where he has so long been an upbuilder. Mr. Hunting is a Fellow and also has been a Manager and Vice-President of the American Institute of Electrical Engineers and prominent in the affairs of the Electric Power Club. He is a member and director of the Fort Wayne Y. M. C. A., member of the Plymouth Congregational Church and a member of the Mohawk Club of Schenectady.

Mr. Hunting has for several years been a Thirty-second Degree Scottish Rite Mason, a Knight Templar and a Shriner, and recently received at Boston, Mass., the Thirty-third Degree of the Ancient Accepted Scottish Rite of Freemasonry for the Northern Masonic Jurisdiction of the United States of America, an honorary degree greatly appreciated by all.

ARTHUR S. IVES

Arthur S. Ives, in company with Rolland A. Davidson, formed the firm of Ives & Davidson, engineers, November, 1911,

ARTHUR S. IVES

and, except for a brief period in 1915 when William W. Cole, prior to his death in the same year, was made a partner, the firm has retained its title to the present day.

Among their early clients was the Claflin Syndicate for which they supervised the electrical equipment of twenty-seven department stores, introducing the new system of interior lighting that marked the abandonment of arc lamps. A novel central heating system supplying seven buildings on separate blocks in Buffalo was successfully installed. Then followed, in 1913, the designing and construction of an addition to the leather tanning plant of

the Creese & Cook Manufacturing Company at Danvers, Mass., including provisions for all machinery and equipment. The building of an electric generating station, and ice-making and cold storage plant, and twenty-seven miles of 33,000-volt transmission line, for the Arizona Gas & Electric Company of Nogales was a project involving a heavy financial outlay.

Further activities embraced investigations into the design, production and operation of stationary Diesel engines in 1915; an investigation and report on aeroplane motors in 1916; the development of a patented process for extracting potash from kelp, undertaken for the Alaska Products Company; and reports on various hydro-electric plants in eight States. The firm made valuation and appraisal of seven public utility properties in Pennsylvania in 1915, and in 1917 and 1918 acted as general manager for twelve public utility properties in the middle and southwestern States. Appearances before state tax and public service commissions on behalf of public utility companies and in the matter of rates, tax assessments, security issues, etc., have been frequent. Other engagements have concerned consulting engineering relations with building managers, brick yards, hospitals, factories, and various industrial constructions.

Arthur S. Ives, though born in Brooklyn, January 3, 1870, comes of old New England stock. Certain of his forefathers left honored names in the Plymouth, Massachusetts Bay, Rhode Island, New Haven and other Colonial settlements. Mr. Ives seems to have been blessed with the inborn attributes of the engineer. His capacities showed themselves at the Columbia School of Mines where he won the C.E. degree at the age of nineteen, took the E.E. degree in 1891, and won an honorary fellowship in mechanical engineering, under the late Prof. F. R. Hutton. Mr. Ives' graduation thesis in civil engineering, a design for a cable driving plant for the Brooklyn Bridge, attracted the attention of C. C. Martin, then chief engineer and superintendent of the bridge, and led to its author's appointment as assistant engineer, a position held between 1892 and 1897 while the rebuilding of the two terminal stations was in progress. Previously, he had taken the student expert course of the Thomson-Houston Electric Company, and during that term was one of three men to install on a Lynn & Boston car the first series-multiple railway controller (old type J) ever put in service.

From 1900 to 1905 Mr. Ives was manager of the Centrifugal pump department of R. D. Wood & Company of Philadelphia, designing and superintending the construction and installation of pumping machinery in plants throughout the country. One installation was of the electric driven centrifugal pumping plant for the sectional floating drydock of the Morse Shipbuilding & Dry Dock Company in Brooklyn. As assistant general manager of the Glamorgan Foundry & Machine Company, between 1905 and 1907, Mr. Ives had charge of plants at Lynchburg and Radford, Virginia, where pipe, hydrants, valves and castings were manufactured to the annual value of $1,500,000. Mr. Ives' services as assistant general manager and consulting engineer to the Poughkeepsie Light, Heat & Power Company were especially notable. Beginning in 1907, he made extensive investigations into the principles of electric rate making, evolved methods for cost keeping, estimated on projected new construction, prepared specifications for transmission lines, worked with various committees on questions of taxation, accounting and rate schedules, designed an underground conduit system for the business section of Poughkeepsie, and finally conducted valuation work on the properties of the Poughkeepsie Light, Heat & Power Company, the Newburgh Light, Heat & Power Company, and the Hudson County Gas & Electric Company, preliminary to the consolidation of these three utilities. Mr. Ives is a member of the National Electric Light Association as well as of the American Society of Civil Engineers. In Masonry he has taken all the York-rite degrees and is associated with the Poughkeepsie Masonic groups.

introduction of great economies in the use of machines and materials, and the minimization of "waste."

Mr. Knight is a member of the Mohawk Club of Schenectady, the Mohawk Golf Club, and the Essex Fells Country Club, New Jersey. His residence is at 57 Douglas Road, Glenridge, N. J., and his office at the Sprague factories, Bloomfield, N. J.

JAMES C. DeLONG

From his start in the electrical field, in 1886, James C. DeLong has filled nearly every position in the scope of the central station from fireman, lineman, engineer upward. He is now president of the Syracuse Lighting Company of Syracuse, New York.

"In looking back over the years," said Mr. De Long to the writer, "the development of the electric industry seems beyond belief. Things which in my early days were dreams are today practical commercial operations."

James C. DeLong was born June 29, 1861, in Utica, N. Y., and in 1879 he was graduated from the Utica Academy. In that year, be it said in passing, the world was beginning to talk about illumination by electricity.

His school-days over, young DeLong went to work in the furniture trade and continued at it for seven years. Meanwhile his youthful enthusiasm centered about the new-born art—electricity—to which have been devoted over 25 years of his active life.

In 1886 Mr. DeLong became manager of the Utica Electric Light Company, later engaging in special construction for Thomson-Houston Company. He was successively manager of the Toledo Electric Company, Toledo, Ohio, and the Eastchester Electric Company, Mount Vernon, N. Y., removing thence to Philadelphia as engineer for the United Gas Improvement Company. The selection of Mr. DeLong as president of the Syracuse Lighting Company followed.

LOUIS H. EGAN

Steady progress, without undue haste, false starts or wasted motions, fittingly characterizes the career of Louis H. Egan, who in 1920 reached the presidency of the Union Electric Light & Power Co., and of the St. Louis County Gas Company, before he was thirty-nine years of age.

Louis H. Egan was born Nov. 21, 1881, at La Crosse, Wis. In 1904 he was graduated from Sheffield Scientific School, Yale University, and in the same year he went to Sault Ste. Marie, Ontario, becoming electrician for the Algoma Steel Company. From 1906 to 1910, Mr. Egan was in Detroit in the service, first of the Detroit Edison Company in its sales department, then in construction engineering, and later as District Manager of the Eastern Michigan Edison Company.

In 1910 Mr. Egan removed from Detroit to Kansas City, to become general manager of the Kansas City Electric Light Company. After six years in that position he was called to St. Louis (1916) as general manager of the Electrical Company of Missouri, as well as vice-president and general manager of the St. Louis County Gas Company. In 1917 Mr. Egan was appointed assistant general manager of the Union Electric Light & Power Company, and in the following year he became vice-president. Two years later he succeeded to the presidency of that corporation. He then became president also of the St. Louis County Gas Company.

JOHN KRUESI

To the late John Kruesi fell the great honor and distinction of making the first phonograph; and none who knew him could grudge that gentle, mechanical genius the glorious immortality thus achieved as to the production of the simple, perfect little apparatus with which for the first time in the history of the race the human voice was recorded. Preserved today in the British Museum, that wonderful pioneer instrument not only embodies a new art but marks the beginning of a new era of progress and civilization. Never was the world presented with a nobler Christmas gift than that made at the old Menlo Park laboratory in the closing days of 1877 by the talented Switzer.

"Honest John" as he was ever called by thousands of friends, associates and workmen, was born at St. Gall, Switzerland, in 1843 and educated in the high school of the famous ancient town. He graduated in 1863, his studies having been varied and including geometry, physics, algebra, drawing, and clay modeling, to which he added a natural bent for mechanics and a wonderful skill and refinement in design. His sense of proportion in engineering, doubtless inherited, was always a matter of comment with those carrying out his instructions. Such qualities as show in the national Swiss manufacture of products as wide apart as watches and water-wheels never had a finer embodiment than in Kruesi; and his whole training gave notable edge and force to his ability. As a lad of 17 he went at once into the shops, and his later military service naturally found him in the artillery. Having "earned his stripes" he promptly indulged his taste for travel by spending his "wander yahre" in traveling over practically all of Europe; and before he came to the United States he had practiced several lines of construction long enough to learn each of them technically —such as sewing machines, tools, printing presses, guns, machinery for making needles, locomotives, hoisting appliances, and large building work.

Arrived in America, in the Spring of 1871, Mr. Kruesi was induced to enter the employment of Thomas A. Edison, then at the very outset of his marvellous career as an inventor, and needing just such a right hand as was now providentially placed at his disposal, as one brilliant conception after another poured from a teeming brain and required the widest range of skill and knowledge to incorporate it in a device, a machine, or even a working "system." Starting with gold and stock "printers," Kruesi ran with Edison through the whole gamut of automatic telegraphs, electric pens, acoustic telegraphs, telephones, microphones, phonographs, incandescent electric lamps, electric motors, dynamos, and railways. From 1876 to 1881, Kruesi was the indefatigable and invaluable, mechanical foreman of that volcano of inventions, Edison Laboratory, his own inventive ability being largely drawn on, while he had endless opportunity, as in the phonograph, to use his really remarkable manual dexterity and deep knowledge of how an infinite number of things could best be made. John Ruskin would have delighted in him.

In 1881 a new stage began in Mr. Kruesi's development. He had assisted at the birth of the Edison electric lighting system, and its father having now decided that the circuits must go underground, Kruesi invented the celebrated underground electric tube system, developing the patent that Edison took out in April. This was the beginning of another quite new engineering art, and into its perfection Kruesi put infinite patience and study, with a pronounced success that had much to do with the prompt acceptance and swift advance of the Edison system throughout the world. Mr. Kruesi was naturally made general manager and treasurer of the Electric Tube Company, until in 1885 it was merged with the Edison Machine Works, of which he then became assistant general manager, a position he held until 1888. Ever advancing in responsibilities and activities, Mr. Kruesi then became general manager of the great consolidation, the Edison Gen-

eral Electric Company, in charge of all the vast manufacturing at all the plants, including the Schenectady Works, as well as those at New York and in Canada. Much to his regret this all involved, however, more or less separation from the chief to whom in the great creative period he had given such loyal and magnificent service; but it was inevitable that Mr. Kruesi should elect to develop the mechanical departments in which he had won distinction and for which ripe experience so admirably fitted him. In 1892, he became general manager of the General Electric Company, and its chief mechanical engineer in 1896. At Schenectady, where the enormous factories ever grew and grew, his was ever the fine outstanding personality it had been from the first moment of his striking hands with Edison; and his untimely death there, February, 1899, was occasion of tributes from the industry, the profession, the press, and coworkers, of unsurpassed affection and glowing esteem. Indeed, the feelings expressed may be summed up in the remark that they placed Mr. Kruesi's contribution to the universal electrical arts and public utilities of the times as second only to those of his great leader, whom he had so brilliantly aided.

Mr. Kruesi's family consisted of eight children, of whom three are girls and five sons. The eldest, August H. Kruesi, worthily continues the Kruesi traditions at Schenectady, N. Y., where he is Chief of the Construction Engineering Department of the General Electric Company. The second son, Paul John, resides at Chattanooga, Tennessee, where his electrical interests include the manufacture of lava insulation and the electric furnace production of steel alloys. June 1, 1922, Mr. Herbert Hoover appointed him Acting Assistant Secretary of Commerce of the United States, in which capacity he is now living at Washington. He is the subject of a biographical sketch which may be found elsewhere in this volume. The other Kruesi children are Mrs. Wayne R. Brown of Schenectady, N. Y., Walter Edison Kruesi of the Home Sewing Machine Company of New York, Frank E. Kruesi of Seattle, Wash., Miss Olga Kruesi of Ithaca, N. Y., Mrs. Waldron N. Slutter of Garden City, N. Y., and John Kruesi, Vice-President of the American Lava Corporation, Chattanooga, Tenn.

PAUL KRUESI

Mr. Paul John Kruesi is the second son of the famous chief engineer of Thomas A. Edison, who built for his immortal chief the first phonograph and heard from it the first reproduction of human speech —"Honest" John Kruesi. Nor was this all, for he had the honor of being born at the Menlo Park Laboratory, February 3, 1878, just at the time the invention attracted the attention of the civilized world and literally opened up the way for the swiftly following invention of the Edison incandescent lamp.

The pioneer Edison Works were in 1886 transplanted to Schenectady, N. Y., where at Union College the young Kruesi was educated, class of 1900, president of his class, managing editor of the college annual, and member of the Sigma Phi. Each year in the summers from 1894, he had tried his "prentice hand" in departments of the General Electric Company at Schenectady, where his father was chief mechanical engineer and general manager of the great works; also with Edison in 1896 at Orange, N. J.; and he then became connected with the Insull electrical interests both in Chicago and in New York. In 1902 he founded the American Lava Company at Chattanooga—the "Dynamo of Dixie"—of which prosperous electrical insulation concern he is now president and sole owner. In 1917 at the same center he established the electric furnace plant of the Southern Ferro Alloys Company, manufacturing ferro silicon, using 6,000 horsepower from the Brady plant on the Tennessee River. He is now also president of that concern, and vice-president of the Tennessee River Milling Company and other like industries. In 1918 he built another furnace at

JOHN KRUESI
(DECEASED)

the suggestion of the War Industries Board, viz., the Chattanooga Electro Metals Company, of which he is president, producing high silicon pig iron electrically —a notable new industry.

Mr. Kruesi is a member of the A. I. E. E., the Illuminating Engineering Society, American Electro-chemical Society, American Iron & Steel Institute, Electric Furnace Association, and the International Acetylene Association. He is past president of the Chattanooga Chamber of Commerce, and vice-president of the Chattanooga Manufacturers' Association; also a director of the Rotary Club and the Red Cross; vice-president of the Muscle Shoals Improvement Association; a former director of the Chamber of Commerce, U. S. A., a regent or trustee of the State University of Tennessee at Knoxville, vice-president of the Tennessee River Improvement Association, member 1920 State Republican Campaign Committee, director of the Hamilton Trust and Savings Bank, and the East Tennessee Iron & Coal Company of Knoxville.

In 1896 Mr. Kruesi married Myra K. Smartt, daughter of the late Capt. James Polk Smartt, historian of the U. S. Government, Chickamauga Park Commission. He has five children, the one boy being named after his distinguished grandfather, John Kruesi, whose eldest son, August H. Kruesi, is at the head of the Construction Engineering Department, General Electric Co.

ERNEST LUNN

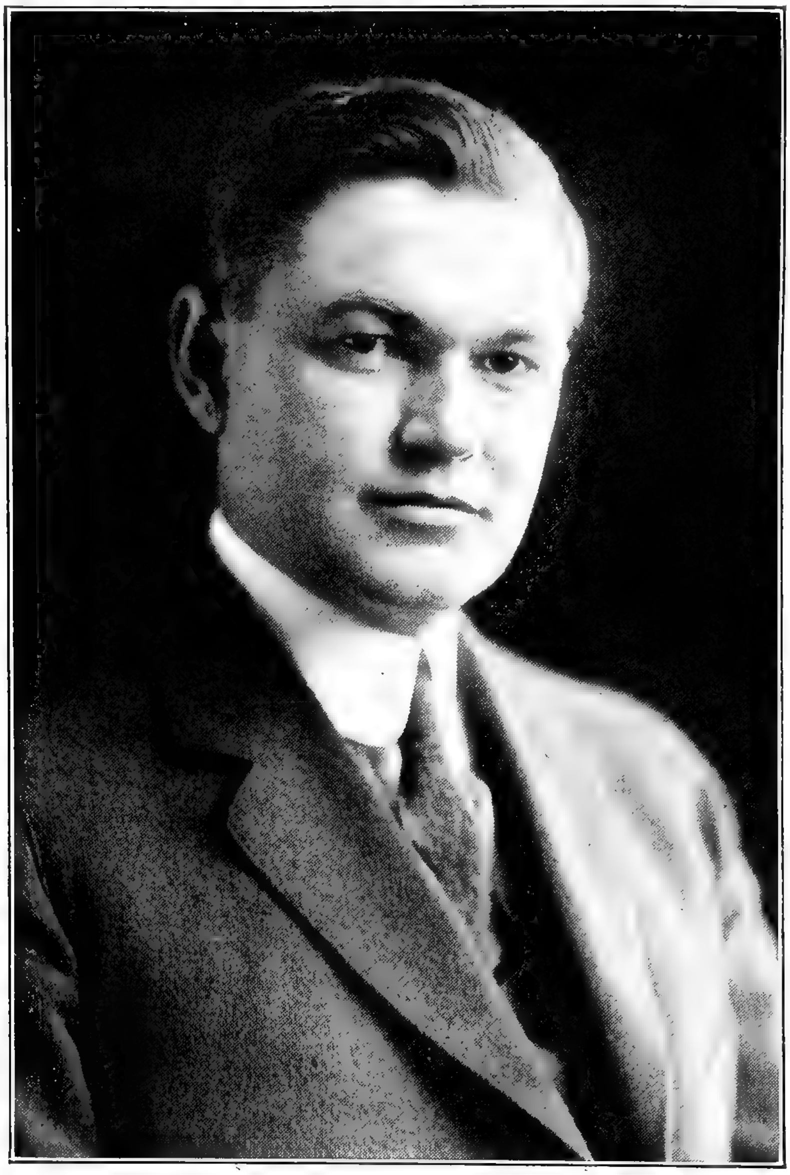
It is a commonplace of literature to comment upon the infinite variety of life and its opportunity; but even yet we are slow to narrow down the application of the truth to the electrical field. One hears incessant repetition of the sapient saying that "Electricity is in its infancy," whereas it is one of the oldest things on earth. One rarely or never hears any remarks on the newness of the illimitable opportunities that *applied electricity* offers to talent and young ambition.

For example, Mr. Ernest Lunn, as the innocent but worthy cause of this reflection, is quite justly entitled to glory in the fact that he was instrumental in developing the electric truck, especially as exemplified in the unique and highly successful product of the Walker Vehicle Company of Chicago. Yet when the present "Story of Electricity" was begun, the possibilities of the electric truck were barely recognized and certainly very few had concentrated on it as Mr. Lunn has done. If today Chicago or New York were to use the electric truck as they could and should, it would take several Ford factories to supply the demand.

Mr. Lunn was born June 23, 1874, near Greenville, Mich., where he received his early education in country school and at the High School, graduating in 1899 from the University of Michigan, being a member of the Tau Beta Pi, Gamma Chapter, and a graduate B. S. (E.E.). Anxious to know the electric lighting industry from the ground up he began his life work in the underground department of the Edison Illuminating Company of Detroit. After six months of that he was transferred to power house reconstruction, then to the drafting department and next was placed in charge of storage battery substations. In 1902 he resigned to move to Chicago, where he was superintendent of storage batteries, Commonwealth Edison Company, 1902-10. In the latter year he put in seven months with the Firestone Tire & Rubber Company, learning that technique; and then returned to the Commonwealth as battery engineer. He retained that position until 1914, when he became chief electrician of the Pullman Company, in charge of whose electrical department he has continued ever since. But in 1903 he assisted in the organization of the Automobile Maintenance and Manufacturing Company, which became the Walker Vehicle Company in 1909, serving successively as secretary and treasurer, vice-president and general manager, and president, resigning only in 1914 to switch over to the Pullman interests, beginning with a special problem in supervising

extensive improvements in the lighting of Pullman cars. This, like his pioneer tasks on the Walker truck, is a highly specialized branch of electrical industry. He was the first to advocate the use of ampere hour meters on central station batteries and on vehicle batteries; and later instituted their use to control battery charging on Pullman cars. While with the Commonwealth Company he devoted considerable time to the storage battery reports of the Association of Edison Illuminating companies, and was a collaborator on the useful manual it issued of storage battery practice.

Mr. Lunn is a member of the American Institute of Electrical Engineers, the American Electro-Chemical Society, the National Electric Light Association, the Western Society of Engineers, the Illinois Athletic Club, and the Olympia Fields Country Club. He is also much interested in the affairs of the University of Michigan Alumni Association of Chicago.



ERNEST LUNN

ROBERT McALLISTER LLOYD

ROBERT McALLISTER LLOYD

Robert McAllister Lloyd, of New York City, is entitled to a place in the history of electricity as one of the engineers whose names were perhaps not prominently identified with specific inventions but whose conscientious work, on the other hand, largely contributed to the advancement of electrical engineering in the early days. Mr. Lloyd, however, has to his credit a large number of electrical devices which he personally designed and put into use, as well as a mass of electrical machinery and various manufacturing processes.

He was born at Elizabeth, N. J., June 14, 1864. His family soon after removed to Philadelphia where he received his early education at the Germantown Academy and where he was prepared for college at the age of 16, but, on account of poor health, instead of being sent to a college, he went to a lumber camp in Western Pennsylvania where he spent a year in the work of the woods and sawmill. Returning from his experience he went into his father's office, who was at that time a banker, and devoted a year and a half to the banking business, when his father, owing to failing health, returned to the old family farm in central Pennsylvania.

Young Lloyd was then obliged to make his own way and went into the employ of a civil engineer and architect at Allentown, Pa., where he remained for a year and absorbed some knowledge of engineering and construction. But he was obliged to abandon this work on account of difficulty with his eyesight and to spend the next year working on his father's farm. It was here that he became interested in electricity, and we must give the young man credit for carrying out his ambitions against adverse circumstances. He obtained books and studied for the examinations which qualified him to enter the junior class of Lehigh University, and with this standing he was able to take a one-year special course in electricity for which he obtained a certificate but no degree.

While in college he was a member of the Chi Phi fraternity, manager of the Dramatic Association, member of the Glee Club, and one of the editors of the college paper, *The Lehigh Burr,* and was accepted on account of his good work as an alumnus of the class of 1886.

After leaving college Mr. Lloyd entered the employ of the Daft Electric Company as an assistant to Mr. Leo M. Daft, a well-known pioneer in electrical engineering. The name of this company was later changed to the United Electric Traction Company and Mr. Lloyd became its chief engineer, succeeding Mr. Daft in 1889. When this company suspended business Mr. Lloyd became interested in the possibilities of electric storage batteries and started the firm of Lloyd & Paxon, Ltd. This firm equipped a small factory for the purpose of manufacturing storage batteries but was obliged to suspend operations through a decision of the courts in favor of the Brush Storage Battery patent; and Mr. Lloyd grasped this opportunity to visit Europe with the object of investigating the storage battery developments there. Upon his return from Europe he was retained by the Electric Accumulator Company as research engineer. This company was one of the parties of the great storage-battery patent litigation and was finally absorbed by the organization of the Electric Storage Battery Company of Philadelphia—again leaving Mr. Lloyd on his own resources.

He then organized the Planté Com-

pany to manufacture storage batteries of the Planté type with a factory in Jersey City. This business was successful and obtained important contracts for large storage batteries and was greatly indebted to Mr. C. O. Mailloux, the electrical engineer, who specified its batteries in a number of installations which he was at that time engineering. Mr. Lloyd had entire charge of the Planté Company, being its president, manager and engineer and was so successful that he attracted the attention of the Electric Storage Battery Company, which so much disliked his competition that they purchased the entire business to the advantage of all concerned, at the same time retaining Mr. Lloyd as consulting engineer.

While Mr. Lloyd was active in the storage battery business he was endeavoring at all times to create fields for their use, and he thus became interested in electrical vehicles, submarine boats and other applications of electric storage batteries. With the late Isaac L. Rice he organized the Electric Boat Company and was its treasurer. He also organized the Appert Glass Company for the purpose of making glass jars for the storage battery business, which company incidentally developed what is known as the Sandwich method of wire glass and was later merged into what is now the great Mississippi Glass Company.

In 1889 the Electric Vehicle Company, which was a large aggregation of capital and manufacturing interests, organized to promote the automobile business, both electrical and gasoline, elected Mr. Lloyd its president. But, as is generally known, this venture was too far in advance of the times and was doomed to failure.

In 1901 Mr. Lloyd started the Vehicle Equipment Company, which was the first manufacturer of any consequence in the electric truck field. This company was reorganized in 1906 under the name of the General Vehicle Company, of which Mr. Lloyd was vice-president and engineer. It was a successful business but was liquidated when the United States went into the Great War.

The electric vehicle was given much attention and thought by Mr. Lloyd and owes much to his endeavors to perfect it for commercial and other purposes. He realized at all times that it had limitations and could only occupy a place secondary to that of the vehicles propelled by an internal combustion engine.

Mr. Lloyd is president and chief owner of Mantle & Company, a machine shop in New York employing about 150 men working on special machinery particularly where precision is required. He is also active in the management of several other industries, and in making scientific researches. He was president of the Siemens & Halske Electric Company of America in 1899 and sold it to the General Electric Company with which he was affiliated for many years thereafter.

Mr. Lloyd's ancestry on the paternal side was altogether English and Welsh-Quaker; on the maternal side Scotch, and Scotch-Irish Presbyterian. He belongs to the Automobile Club of America, Downtown Association of New York, The Piping Rock Club, Long Island, is a life member of the Y.M.C.A. and a member of the First Presbyterian Church of New York. He belongs to the following engineering societies: American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, Society of Automotive Engineers, American Electro-Chemical Society, Society of Refrigerating Engineers, Institute of Electrical Engineers of Great Britain, and was five years in Squadron A, National Guard of New York.

Continually studying new subjects, Mr. Lloyd takes pleasure in advancing his own education for the enjoyment which it brings to him. For many years his ambition was to retire from the commercial fields of engineering and devote his life to scientific research work, but he has been forced by circumstances to remain at the desk of a business office while his thoughts were in a laboratory.

In 1896 he was married to Miss Maitland Belknap, daughter of Robert Lenox Belknap of New York. They have three children; Robert McAllister Lloyd, Jr., Jennet Remsen Lloyd, and Gwendolyn Lloyd.

CARL K. MAC FADDEN

CARL KENDRICK MacFADDEN

Without deeming it at all necessary to compile lists of names in support of the statement, attention may well be directed to the fact that many of the leading men associated with the development of the oil industry have been connected also with the advances in electrical application. The remark applies no less to the earlier days of electrical utilization—say forty or fifty years ago—than to the activities of the present moment. Nor is the transfer of energies from the one field to the other at all surprising, for they are very much alike in the demand they make for engineering skill and administrative ability.

An illustration of this proposition is found very appositely in the career of Mr. Carl Kendrick MacFadden. He was born, quite fittingly, one would say, in Wells County, Indiana, August 6, 1872, coming of Scotch and English stock transplanted to American soil before the Revolutionary War. Some of his forbears had much to do with the pioneer development of three old States—Maryland, Ohio, and Indiana—and then of the Far West, basing in Chicago, where young MacFadden was educated. He specialized in technical studies, and in the period 1887 to 1898 was prominently identified with electrical engineering in particular. Not only was he an early member of the American Institute of Electrical Engineers but he was one of the founders of the American Electro-Chemical Society. Moreover, he is the author on a well-known book on electrical engineering. All this was supplemented by professional work and a number of electrical improvements and inventions in general use. A wide variety of electrical interests is thus indicated.

Around 1895 by various natural processes of evolution, Mr. MacFadden became very much interested in lines of engineering related more particularly to the petroleum industry, specializing in pipe lines and pumping station construction. For all of this his previous training with its foundation of sound scientific knowledge proved of great value. As a petroleum engineer, he became widely known at once in the oil fields of Latin America, which had made a great appeal to his judgment and intuitions; and there at once a deep imprint was set by his successes. He traveled extensively all over Central and South America and the West Indies, mastering the situation, probing the facts, and becoming in all vital essentials a master expert. Sifting out all the real possibilities broadened also his commercial aptitudes and his desire to foster American trade; and it was a natural sequence that, for example, he was one of leading spirits in the organization of the American Chamber of Commerce of Colombia.

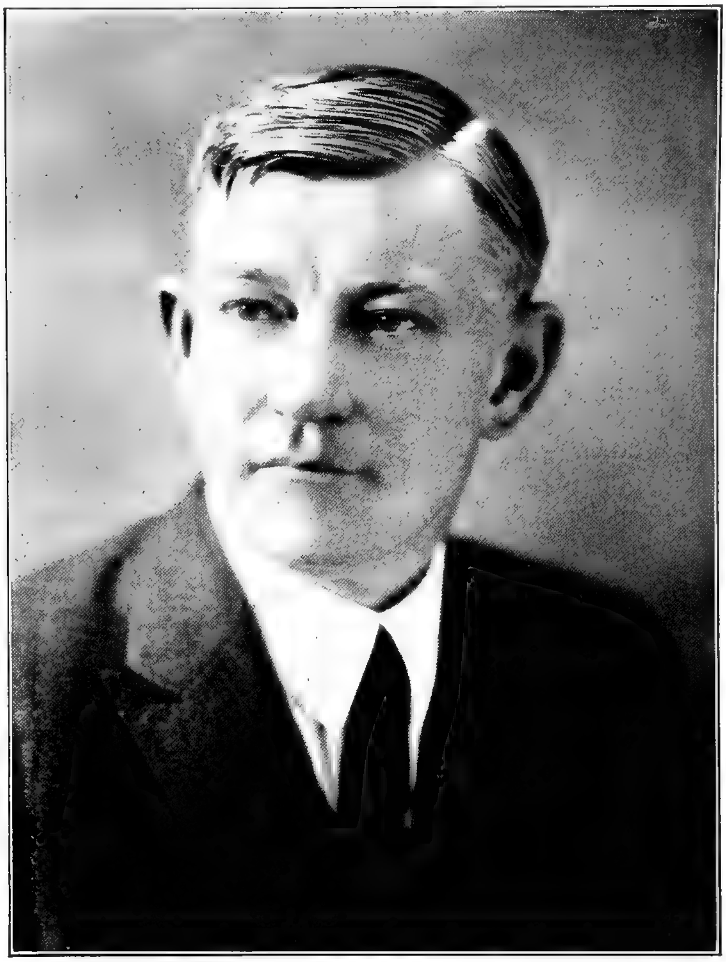
Thus is briefly summed up work that finds him today as its result, chairman of the board of directors of the Carib Syndicate Ltd., the Carib Trading Company, and the Colombian Emerald Syndicate, Ltd; the Colombian Petroleum Company, the Tampico Syndicate, Ltd., the Colon Development Company, the Normacson Corporation, and the Corporation of Industrial Engineers. He has his headquarters at the main office of the Carib Syndicate, 90 West Street, New York.

A wide range of interests is attested by Mr. MacFadden's social and engineering affiliations. In addition to the two national engineering bodies, named above, he is an associate member also of the Society of Naval Architects and Marine Engineers and a member of the Institute of Petroleum Technologists of England, and of many bodies engaged in geological or geographical work. He is a director of the American Bison Society, and member of the Bankers', Meridian, Transportation, National Arts, Explorers', Adventurers' Clubs and Campfire Club of America.

Mr. MacFadden served on the examining committee of the Naval Consulting Board of the United States, attached to the New York office.

McCLELLAN & JUNKERSFELD

One of the leading engineering events in the Spring of 1922, as the present volume of "The Story of Electricity" was passing through the press, was the organization of the firm of McClellan & Junkersfeld, Inc., the first mentioned having been a Consulting Engineer of long experience, and now President of the American Institute of Electrical Engineers, and the other, for many years an Executive of the Commonwealth Edison Company, and later Engineering Manager with the firm of Stone & Webster, Inc.



WILLIAM McCLELLAN

Dr. William McClellan, born November 5, 1872, at Philadelphia, Pa., was educated at the University of Pennsylvania, graduating B. S., in 1900, Ph.D. in 1903 and E.E. in 1914. His college fraternities were Alpha Chi Rho, Phi Beta Kappa, Sigma Xi, and Beta Gamma Sigma. Immediately upon leaving college he began his active career as an engineer with the Philadelphia Rapid Transit, while serving at the same time as an instructor in physics in the University. Therewith a life work of unusual distinction was outlined. For several years Mr. McClellan was a managing engineer for the famous old house of Westinghouse, Church, Kerr & Co., participating in the Pennsylvania Railroad Terminal engineering and construction, and in the electrification of the Rochester Division of the Erie Railroad. Subsequent to that he engaged in various consulting

and engineering work with the firm of McClellan & Campion, and served as chief of the Division of Light, Heat & Power of the Second District Public Service Commission of New York State. For Bureau, an organization giving valuable service during the Great War and made up of over 200 of the leading colleges of the country. He has been a lecturer on Public Regulation at Yale University, and

COL. PETER JUNKERSFELD

eight years he was associated with the Cleveland Electric Illuminating Company, and was one of its vice-presidents for two years. In 1922, he became president of McClellan & Junkersfeld, Inc., engineers and constructors.

Outside of all this professional occupation, Dr. McClellan has devoted time in many ways to public and semi-public matters, having, for example, been Dean of the Wharton School of the University of Pennsylvania for several years; as well as director of the Intercollegiate Intelligence has contributed articles on economic and kindred subjects to leading magazines. In numerous public addresses he has also dealt authoritatively with these subjects, both from the esoteric and the broader national viewpoints.

Always deeply interested in the work of engineering societies, Dr. McClellan has long given valuable service in particular to the American Institute of Electrical Engineers, to whose presidency he was elected in 1921. He is also a member of the Executive Board of the Federated En-

gineering Societies, seeking through both notable agencies to give effect to many cherished ideals relative to the position and duties of the engineer as a servant of the community. His doctrine is that the engineer should not restrict himself to the narrow conservatism of a colorless technician; and he practices boldly what he preaches strenuously.

Dr. McClellan is a member also of the American Society of Mechanical Engineers, National Electric Light Association, American Electric Railway Association and kindred bodies. He is a member, in addition, of various clubs, among them the Engineers' of New York, Bankers', India House, University of New York, Philadelphia and Washington, University of Pennsylvania Club of New York, Cosmos Club, Washington, D. C., Huntington Valley Country, and Huntington Valley Hunt clubs of Pennsylvania. His home is at Bethayres, Pa.

In many ways Col. Peter Junkersfeld is as typically Western as his colleague is Eastern in training and career. He was born October 17, 1869, at Sadorus, Ill., and was educated at the University of Illinois, graduating B.S. in engineering in 1895, and E.E. in 1907, his fraternity being Tau Beta Pi. In the period following the Columbian Exposition and the revival of American industry, Junkersfeld joined the forces of the Chicago Edison Company, and serving in various operative capacities in the power plant, advanced through the mechanical and electrical departments of that great corporation to a position in charge of the engineering and construction departments of the company. As a result of the efficient discharge of such duties, he became assistant vice-president, supervising contracting, construction, engineering, and operation of steam stations aggregating 600,000 k.v.a., together with the related transmission, distribution and other physical properties; and, during this period took on commercial activities, especially electric service negotiations and power rates in connection with such work. Mr. Junkersfeld was also consultant, and for five years chairman of engineering and operating conferences of allied utilities in several states. He was also president for one year of the Association of Edison Illuminating Companies.

Then came American entry into the Great War. In June, 1917, Mr. Junkersfeld entered the Construction Division, U. S. Army, becoming successively Major, Lieut.-Colonel, and Colonel. In this service his work was of tremendous importance and responsibility, and he was occupied day and night in supervising and directing, along all branches of engineering, the construction of cantonments, camps, hospitals, port terminals, warehouses, and other vital military projects. Following that military chapter, he became engineering manager of Stone & Webster in charge of the Engineering Department, and an executive of the Division of Construction and Engineering, during a period in which no less than 300,000 k.v.a. in steam and hydro plants was installed together with 20,000 boiler horse power in various boiler plants and industrial enterprises. In February, 1922, Col. Junkersfeld resigned to become, as noted, a member of the new firm, in direct charge of a number of engineering and construction projects.

In spite, or perhaps because, of all this activity, Col. Junkersfeld has found time for several papers read before engineering bodies and articles in the technical press relative to public utilities and engineering topics. He is a member of the American Institute of Electrical Engineers, the American Society of Civil and Mechanical Engineers, National Electrical Light Association, American Electric Railway Association, Franklin Institute, the Western Society of Engineers and the Edison Pioneers. He is also a member of the University Club of Chicago, Chicago Athletic Association, the Engineers Clubs of New York City, Chicago, and Boston, and the Lawyers' Club of New York City. His home is at Hartsdale, N. Y.

The firm of McClellan & Junkersfeld, Inc., has its headquarters at 45 William Street, New York City.

GEORGE A. McKINLOCK

Mr. George A. McKinlock is one of the strong and successful men of the electrical industry and is a well-known leader in the social and financial life of his home city

GEORGE A. McKINLOCK
President, Central Electric Co., Chicago

of Chicago. His electrical house—one of the first to be organized—was established in 1887, and has grown and expanded under President McKinlock's far-seeing direction, and is today probably enjoying the most extensive business of any company devoted exclusively to the marketing of electrical supplies in the United States. The Central Electric Company has established and made famous in the electrical industry the well-established claim of "The House of Service."

Mr. McKinlock owns a beautiful house surrounded by many handsomely wooded acres in the select Chicago suburb of Lake Forest and is largely interested in Chicago city property.

Mr. McKinlock may be classed as a genuine pioneer in the development of the use and adoption of all varieties and improvements in electrical supplies and appliances and has contributed a large and honorable share to the rapid and important growth of this comparatively new field.

Lieutenant George Alexander McKinlock, an only son, left his father's business to do his patriotic duty in the war and lost his life in France, shot down by a German sniper while he was acting as liaison officer for the general in command. Lieutenant McKinlock had received several citations for bravery and gallantry while under fire. He was awarded the D.S.C. and Croix de Guerre with Palm. His sad death is not alone mourned by devoted and loving parents but by scores of home friends and among his fellow graduates of Harvard University and other friends in the officers' training camp where he and other loyal sons prepared themselves for their country's need. In memory of this son Mr. McKinlock has presented to the Northwestern University of Evanston, Ill., "The Alexander McKinlock Memorial Campus" and to the Chicago Art Institute, a large fund to aid its plans for building and extension of facilities.

Mr. McKinlock and his wife have been interested travelers to many unusual parts of the world. His library is extensive and carefully selected and many hours are spent by him in adding to his remarkable knowledge on a great variety of philosophical, classical and literary subjects.

HON. WILLIAM B. McKINLEY

Spanning the Mississippi river at St. Louis, Mo., is the largest electric railway bridge in the world. This structure, a mile-and-a-half in length and possessing heavier carrying capacity per foot than any other bridge across the Mississippi river, was conceived, planned, financed and built by Hon. William B. McKinley, present United States Senator from the state of Illinois, and president of the Illinois Traction System. Across its spans are operated the modern electric passenger and freight trains, which have done so much to stimulate commercial and social relation between the states of Illinois and Missouri, and have opened the St. Louis gateway to an enormous territory hitherto unblessed with transportation facilities.

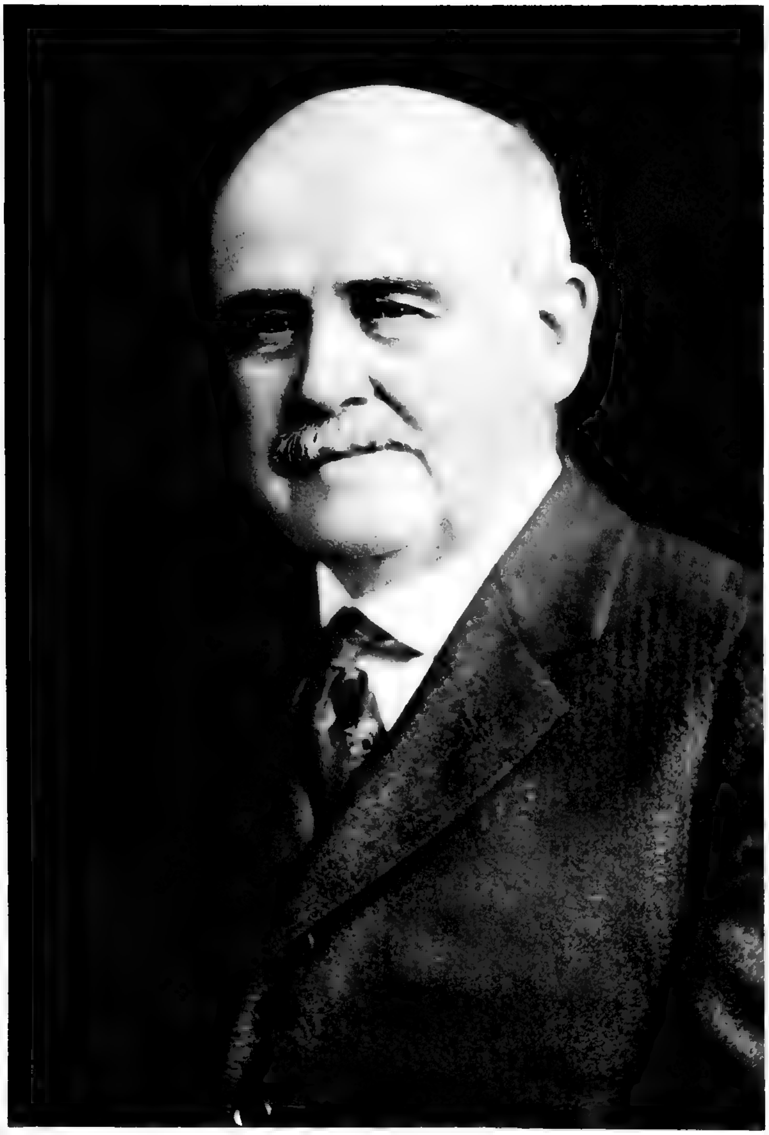
This bridge stands today as a monument to the foresight and energy of a son of Illinois who, from humble beginnings in the field of public utilities, has advanced in this industry until one of the largest electric railways in the world—the Illinois Traction System—bears his name and is better known by the millions of people in its territory as "The McKinley Lines."

The name of McKinley in Illinois suggests a public service well planned and well performed. It is almost equally well known in Missouri, Kansas, Iowa and Nebraska, where many public utility properties are operated by his organization. While the McKinley utilities cover the field of gas, steam heat and other services it is to the electric industry that he has given most attention. His application of electricity to the transportation problems of his native state with subsequent construction of the most highly developed electric carrier in the middle west has made the name of McKinley synonymous with energy, progressiveness and stability, not only in the territory served by his utilities, but in the general electric field as well.

McKinley's first interest in electric utilities was not that of a technically trained man. He had made his own way through the Illinois Industrial College at Champaign, Ill., now known as Illinois University, and had successively served as a clerk in a drug store and bookkeeper in a country real estate office, when he saw the need in his home city, Champaign, for a water works system. This was the start of his activities in the utility field, for although his first enterprise was not a financial success it was a satisfaction to his civic ambitions. He next foresaw the future of the electric street railways. Securing the necessary financial support through connections made in the farm loan business he purchased a decrepit mule car line connecting the cities of Champaign and Urbana and converted it into one of the first electric street railways in the United States.

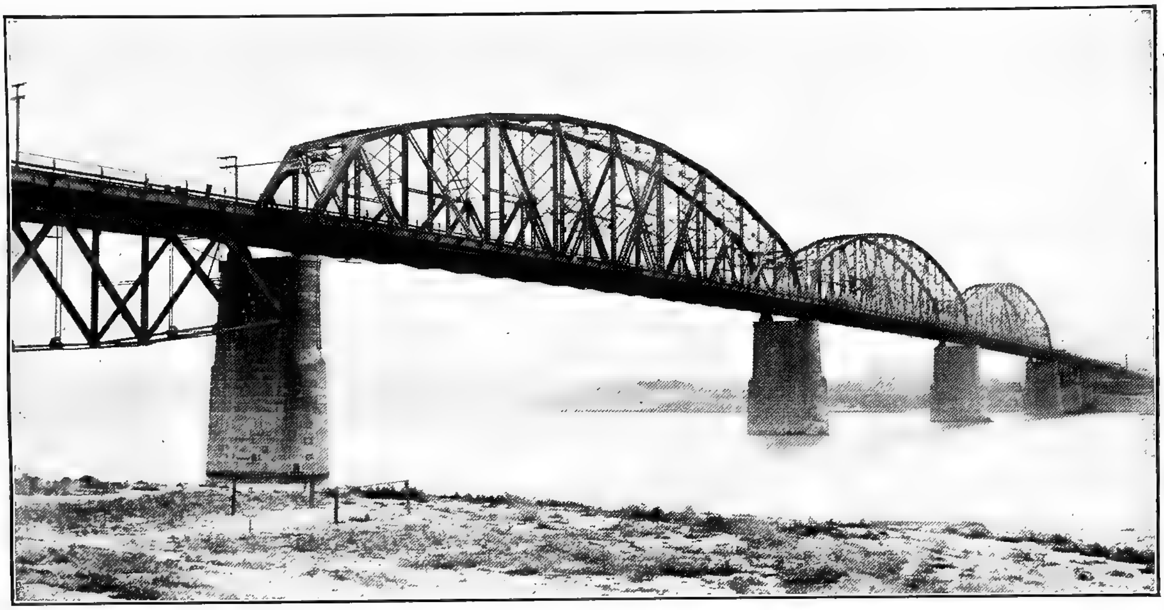
The panic of 1893 put a halt to plans for further utility developments, but in 1896 McKinley, irrepressible, again began to work out his traction plans when he started one of the first electric interurban railway developments in Illinois with an eleven mile line out of Joliet. It was his intention to build into Chicago, but plans were changed and, after disposing of this property, he bought and modernized the street railway lines in Quincy, Ill., then in Galesburg, Ill., whence he built an interurban line into Knoxville, Ill.

In 1901, with the purchase of the street car lines in Danville, Ill., the present McKinley system of electric railway lines was really started. First, spur lines were built out from Danville to nearby mining towns; then Danville and Champaign were connected up. After this, the lines were gradually extended to other important points in central Illinois with St. Louis as an objective, the crowning feature of his plans being the building of the monster bridge across the Mississippi river, which gave his railway the only independent entrance into the Missouri metropolis and broke a transportation precedent that had existed for decades. The bridge, conceived and financed by Mr. McKinley, designed by Ralph Modjeska and affording vehicular



WILLIAM B. McKINLEY

entrance into St. Louis as well as carrying the electric trains of the Illinois Traction System, was completed in 1910, and, together with modern freight and passenger terminals almost in the heart of St. Louis represented an investment of upwards of six million dollars.



The McKinley Bridge at St. Louis. Named in honor of Senator Wm. B. McKinley, its builder. Largest bridge for electric trains in the world

From the beginning, the construction work of the McKinley system of electric railways was planned by the highest grade of engineering ability. The general construction plan included the building of a track and roadway comparable in every respect with that of the steam railway, and so designed that the heaviest freight and passenger equipment might be economically handled. As a result of these far-sighted plans, this company is now operating "through" electric trains over greater distances than any other electric railway or combination of electric railways in the world, and it is an important factor in transportation in Central Illinois and the St. Louis territory. It offers such refinements of service as parlor and sleeping cars, automatic block signals, belt lines around cities for handling of freight, direct connection with mines, elevators and large industries, physical connection and traffic relation with all steam roads, and handling of standard railway equipment, both freight and passenger.

While developing his vast interurban system, William McKinley was also acquiring and modernizing a group of local public utilities which now extends into five mid-western states. The Illinois Traction System, with its subsidiary companies, furnishes electric light and power to 84 cities and villages, operates street railway service in 24 cities, provides gas service in 14 cities, heating service in 9 cities, as well as several miscellaneous water and ice plants.

Although primarily a business man, Mr. McKinley has in later years given a large part of his time to serving the people of his state, first in the House of Representatives at Washington and at the present time in the United States Senate. He was first elected to Congress from the 19th Illinois District in 1904 and served in that capacity for seven terms. His work in the House of Representatives was broad and constructive, as have been his business ideals. Soon after his election, he was a member of the party which went to the Philippines with William H. Taft, then secretary of war, in 1906. For 7 years, he was treasurer and chairman of the

National Republican Congressional Committee. He served on various important committees in Congress and became a leader, recognized as one of the influential members of the House. In 1920, the people of Illinois elected him United States Senator; and in the Senate he is applying the same business-like methods in the handling of affairs referred to him from the higher branch of the federal government.

Mr. McKinley has visited personally every foreign country in the world, and is a deep student of economics and foreign affairs. He retains his residence, when not at Washington, in Champaign, Ill., where as the son of a Presbyterian minister he laid the foundation for a successful career that has not only placed him high in the world of business and politics, but also meant much for the growth and progress of the State of his birth.

SAMUEL H. MARTIN

The career of Mr. Samuel H. Martin illustrates alike the opportunities presented to Europeans in the United States and the possibilities of the electrical field. Born near Belfast, Ireland, November 25, 1874, and educated under the excellent school system of the "Green Isle," young Martin ventured across the Atlantic at the receptive age of 18. He came of good old Presbyterian stock, and was the son of William Martin and Margaret A. (Scott) Martin. Ready, like many another newcomer, for any work, he first accepted employment on a farm of Wisconsin, but felt the lure of Chicago in the great World's Fair year of 1893, and gave faithful service in a dry goods store for over two years, meanwhile rounding out his education by study at the Y. M. C. A. and at the Lewis Institute in Chicago. Attracted to the electrical field in 1895, he was employed for some time by the well-known Gregory Electric Company of Chicago. Associated with some other ambitious coworkers, he next started a company of his own in the power field to handle new and second-hand electric motors, and prospered not only because of steadfast application to an expanding business, but because an intimate knowledge of electrical apparatus had revealed to him many avenues of advance and improvement in its design and construction.

To one branch of electric manufacturing, in particular, Mr. Martin began to give attention—that of the rotary converter for alternating and direct current work. The use of such apparatus in large sizes has been one of the features of modern power transmission enterprise and development, but, as is well known, the use of smaller sizes has hitherto been retarded and neglected mainly on account of the difficulty in starting; and preference has been shown for the motor generator and the rectifier. It is to the credit of Mr. Martin that he has changed these conditions, and by producing an excellent rotary converter has won for it a large sphere of usefulness and popularity. This is specifically true of the growing field of garage work, automobile charging, etc. The old troubles and disadvantages in starting have been entirely overcome, and the machine can be started as easily as any ordinary induction motor. High voltage in the shunt fields is entirely eliminated by means of an ingenious damper ring introduced between the armature and pole pieces, and acting as a magnetic screen for the armature flux, which is thus diverted through the magnetic circuit of the damper ring instead of the magnetic circuit in which the shunt fields are placed. The Martin damper ring forms a continuous laminated magnetic circuit from pole to pole, and has alternate slots and squirrel cage bars on the inside periphery. The riveting or welding of the squirrel cage bars to the copper end rings gives this improved converter the desirable starting characteristics of an ordinary induction motor and prevents "hunting" when once in step and under load conditions. The apparent paradox involved in the construction is in reality the secret of its success and efficiency. The continuous

SAMUEL H. MARTIN

iron laminations of the damper ring would seem to short circuit the flux from the field poles, but as a matter of fact this is only true when starting up, and is necessary to prevent high voltage in the shunt fields. In the slots of the ring are placed the series windings which prevent magnetic leakage from pole to pole when the rotary is under load. Hence the "Martin" rotary will not run away. Any desired voltage regulation is obtainable under the principles of design adopted. The Martin rotaries are built to operate on 110, 220 and 440 volts, and 25, 30, 60 cycles, delivering direct current of any voltage up to 250; and the sizes range up to 100 kw. polyphase and to 3 kw. in singlephase.

The Northwestern Electric Company, which builds this machinery as well as the Martin synchronous motor was started with a modest capital of $10,000, which has grown to $200,000, and it was incorporated in 1903 with Samuel H. Martin as president; E. P. James, vice-president, and Maurice J. Clark, secretary. The headquarters of the concern are at 408-416 South Hoyne Avenue, Chicago, Ill.

Mr. Martin was married April 16, 1903, to Miss Emma C. Miller, of Chicago, and has a family of one son and four daughters. He has not taken any active part in technical society work, but is interested in Presbyterian Sunday School promotion, and has a keen professional interest in motoring and automobile progress, particularly the garage end of the industry.

The Northwestern Company has several other lines of production, notably some excellent variable and constant speed polyphase induction motors. Its "die-cast" rotor for use in the squirrel cage induction motors is a well-known feature —to mention but one specialty.

The Northwestern slip ring induction motors range in build from ½ up to 10 h.p. They are admirably designed for variable speed or for constant speed where their application demands high torque with slow starting current. They are easily reversible with proper controllers such as those of the well-known Cutler-Hammer type.

W. H. MEADOWCROFT

W. H. Meadowcroft was born in Manchester, England, May 29, 1853, and came to America in August, 1875, since which time he has resided continuously in this country. For a few years previous to coming to America, he was assistant chief clerk in a law office. Shortly after his arrival in New York, he entered the employ of Carter & Eaton, a well-known law firm of that day, with whom and their successors he continued for nearly six years. Young Meadowcroft took a five years' course of study in law, and was duly admitted to the New York Bar in May, 1881.

It thus happened that Mr. Meadowcroft fell into very close association with Major S. B. Eaton, a member of the firm, who in the early part of 1881 accepted an invitation from Mr. Thos. A. Edison to become the vice-president and general manager of the new Edison Electric Light Company, the parent corporation for all the Edison incandescent lighting development. Major Eaton invited Mr. Meadowcroft to become his assistant. The offer was gladly accepted, but Meadowcroft pushed through to his bar examination, and then in May, 1881, entered the service of the Edison Company at famous old "65 Fifth Avenue" under the Major. In this employ Mr. Meadowcroft remained for four years, taking a most active pioneer share in the creation of the great new industry, and having the privilege during those early eighties of writing the first commercial literature concerning the incandescent electric light. This creative work gave the young lawyer a chance to indulge

his strong literary taste and show his descriptive ability in the bulletins and circulars now so scarce and highly prized. During this formative period also he became secretary of the Edison Electric Light Company of Europe, Ltd., and of the Edison Ore Milling Company. He served besides on various directorates and as secretary of sundry companies, including the Electric Railway Company of the U. S. A., based on the patents of Edison and Stephen D. Field. Through this latter work Mr. Meadowcroft enjoyed a very close acquaintance with Cyrus W. Field, who took a keen interest in his nephew's inventions as applied to the Manhattan Elevated.

W. H. MEADOWCROFT

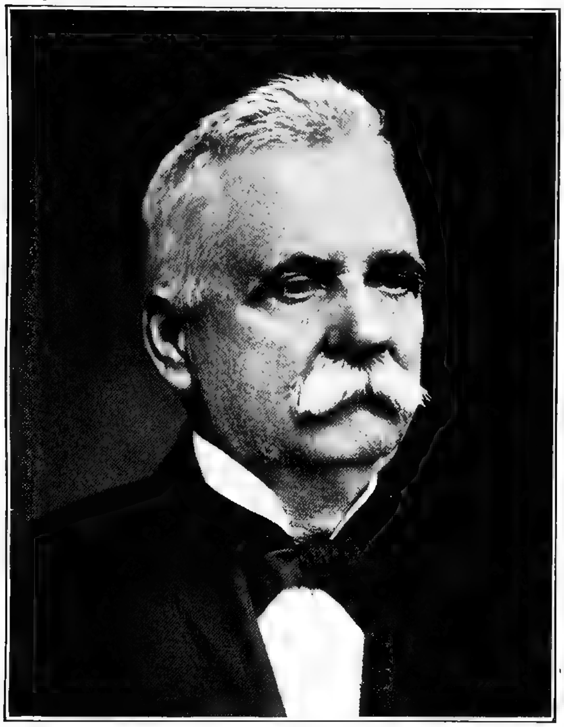
About the beginning of 1885, Mr. Meadowcroft had some farsighted intuitions as to the future of the "miniature" incandescent lamp, and breaking away from these earlier relationships, he organized with two friends a company to develop that branch of the new industry. A great deal of novel pioneer work was done, including the construction of primitive electric signs, but it was another case of being ahead of the times. Mr. Meadowcroft went back into the Edison Company and became a little later assistant to the manager of the Edison Lamp Works at Harrison, N. J. Once more essaying literary work, he wrote the celebrated little primer the "A, B, C of Electricity," which up to 1920 has had a sale of over 100,000 copies.

Being run down in health, Mr. Meadowcroft left his position, made a trip around the United States, and returned to his connection with Major Eaton, who as a partner in Eaton & Lewis, was general counsel for the Edison lighting interests. Three years after, he went back to the Harrison Works, as secretary of the Edison Miniature & Decorative Lamp Department, continuing in that capacity for seven years, helping to lay the foundations for a now enormous industry in small incandescent lamps. The discovery of the Roentgen X-Ray found Meadowcroft still at Harrison, whereupon he began to experiment with it and induced the company to go into the manufacture of Crookes tubes and apparatus. In addition to his regular work, he took charge of the X-Ray Department, developing it for some three years. At this time he wrote the "A, B, C of the X-Ray," one of the earliest books on that fascinating subject.

Early in the present century Mr. Meadowcroft tried his by-no-means prentice hand at storage battery improvement, but neither that nor some later interests could keep him long out of the Edison fold, to which he returned in 1908, going this time into direct personal relations with Mr. Edison himself, in whose service at the laboratory he has since continued. During the early part of this connection he gave valuable assistance to Messrs. Dyer and Martin in the preparation of their two-volume biography of Edison, and wrote his own popular "Boy's Life of Edison." He became assistant and confidential secretary to Mr. Edison in the fall of 1910, a position he still holds with great acceptability and fitness. Mr. Meadowcroft is a founder member and historian of the Edison Pioneers.

ALEXANDER MUNGLE

One of the phenomena of mechanical and engineering development in America has been the prominent and successful part played by Scottish engineers, particularly those from the shipbuilding field and from



ALEXANDER MUNGLE

the great yards that lie all around the teeming city of Glasgow and occupy every sinuosity of the crooked, muddy Clyde. Names of such men will spring at once to the recollection of every one who has been acquainted with big ships and big engines in the United States; and for electrical engineers of the present day it will suffice to mention such masters of their profession as Frederick Sargent and Alex Dow. It has been a splendid body of able craftsmen, draftsmen, designers, experts. They probably have not made much out of it themselves, all told—though Scotchmen; but just as Andrew Carnegie did in building up the steel industry they have contributed immeasurably to the wealth and prosperity of the country of their adoption. To this group or fellowship belongs Alexander Mungle, apprenticed as a machinist in old Scotland to Strathearn, Murray & Patterson, engine builders, at Coatbridge, near Glasgow. From them he came while yet a callow youth to this country in 1869, and finished his apprenticeship with a "brither Scot" at Hoboken, N. J.,—John Maclaren, builder of stationary and marine engines. In spite of its Teutonic flavor, Hoboken is intensely American, enough to be the seat of the Stevens Institute of Technology, which grew out of the pioneer work of the Stevens family on the first American locomotives, steamboats, war monitors and other machinery of the new era. Thence, Mr. Mungle went to the South Brooklyn Engine Works at Brooklyn, N. Y.; next, to the Henry R. Worthington Hydraulic Works; and next again to the old Delamater Iron Works, at the foot of West Thirteenth Street, New York. In 1879, Thomas A. Edison loomed up with his incandescent lamp, opening a new vista to the steam engine and to mechanical appliances in general. Mr. Mungle found a novel opportunity at Menlo Park, that year, being employed in the famous old Edison Lamp Factory, fitting up the gas machine, laying gas pipes and arranging blow pipes for the glass blowers; as well as making machines for sealing and annealing the incandescent lamp bulbs, and doing other work of the kind around the machine shop. In 1881, Mr. Mungle left the Edison employ to go with the Davidson Steam Pump Company, by whom he was employed for over eight years erecting their pumping engines for water works, etc. Once back in this familiar field, he was associated with the Worthington interests for over twenty years at the hydraulic works in Brooklyn.

Mr. Mungle is now in business at 246 Canal Street, New York City, under the name of The Mungle Engineering Company, general machinists and engineers. He and his son, James Alexander Mungle, comprise the firm so that the "succession is provided for" in furtherance of a career that covers one half of the last century of engineering and embraces the first quarter of the Twentieth.

GUIDO PANTALEONI

Chiefly on account of his own reticence, little of the credit to which he is entitled has ever been given to Mr. Guido Pantaleoni, of St. Louis, Mo., the beloved *fidus Achates* through many long years of storm and success, of the late George Westinghouse. The all too brief biography which appears of the great inventor in this volume will, with the approval of all the friends and admirers of both men, receive a worthy pendant in this tribute to the talented Italian to whom the great American was so strongly attached in the early "eighties"; both, thereafter in close association, building up the wonderful record without which, indeed, this "Story of Electricity" could not have been written.

While in Italy in the early part of 1882, placing his airbrake system in Europe, Mr. Westinghouse made the friendship of Doctor Diomede Pantaleoni, an eminent physician, whose son, Guido, had but recently graduated from the old University of Turin. Another son is well known throughout the world as a political economist, a Professor at the University of Rome, and for many years Member of the Italian Parliament. It was a talented and distinguished family whose valuable acquaintance Westinghouse thus made.

Keenly alive to all progress in the arts, the Pantaleonis were at that moment interested in the ingenious scheme of a fellow Italian for making a substitute for marble out of gypsum. All such new ideas contained a ready appeal to the brilliant young American inventor; he took kindly to this one, secured the rights for the United States, and sent young Guido Pantaleoni over the Atlantic with another young man named Albert Schmid, to start manufacturing the product in this country. If the material had possessed any real merit it would certainly have been safe in such hands. But marble, as manufactured in Nature's own laboratories, sustained the rivalry without a dent, and Mr. Westinghouse found himself with a worthless process on his hands, but with two very valuable young men for compensation. He soon transferred Guido Pantaleoni to his Union Switch and Signal Company at Pittsburgh; while Schmid began the career, told on other pages, which made him one of the most notable among the many engineers developed under the Westinghouse leadership and auspices.

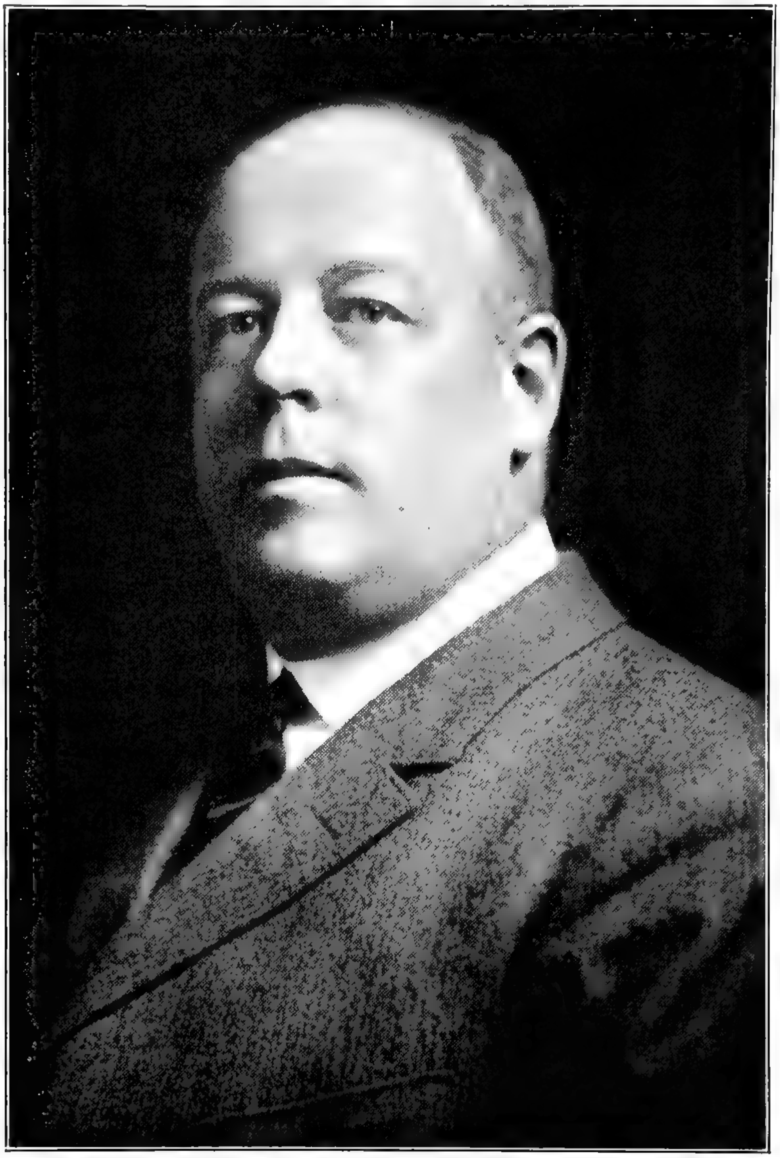
Called back to Italy in May, 1885, by the death of his father, Guido naturally looked up his old Professor, Galileo Ferraris, at Turin. Through the intervention of that fertile physicist he met Lucian Gaulard, who had installed between Lanzo and Circe a novel alternating current system, soon to be known to all men as the Gaulard and Gibbs sys-

tem, the universally recognized starting point of all the vast development of electrical power generation, distribution and transmission with which the name and genius of Westinghouse will remain forever associated. Gaulard was a talented, erratic, young Frenchman. Gibbs was a nervy English sportsman. The crude "transformers" had been shown in London in 1883, in Turin in 1884, and scientific opinion was not then, or for some time later, favorable. But Pantaleoni, with swift intuition and a marvelously prophetic vision, was at once so profoundly impressed that he cabled Westinghouse a description of the new system. Immediately came the reply to secure the patents for America; off to London went the eager Pantaleoni; and then to these shores, bringing a new world with him, came the young Italian to hand his chief the desired option. Few episodes in electrical advance have been more providential, sensational or fruitful. One more "scientific toy" was soon turned into a magnificent tool for the master hands of the electrical and mechanical engineers of the world.

For thirty years—1884-1914—Guido Pantaleoni devoted his energies and abilities to the upbuilding of the new arts and the new factories from which the splendid Westinghouse appliances have come. The broad narrative of it all, as already intimated, is scattered over many pages of this "Story of Electricity." The intimate details of many faithful incidents could only be given by Mr. Pantaleoni, whose Sphinx-like silence as to his own notable share will leave the world forever in wonderment and conjecture, unless, happily, he should leave memoirs as invaluable sources for future historians. Meantime it may be noted that recognition is given suggestively at least to Mr. Pantaleoni's memorable part in it all, in the recent classical "Life of George Westinghouse" by H. G. Prout, from which work a vivid idea may be formed of an uncommon versatility extending over the whole range of personal interest and endeavor—engineering, manufacturing, financial, executive—all directed shrewdly and sagaciously, with profound devotion, to the greater story of his beloved friend—George Westinghouse.

FARLEY OSGOOD

In the two leading electrical bodies of America, Mr. Farley Osgood has already made a deep imprint by his useful constructive work, as can readily be seen by reference to the publications of the American Institute of Electrical Engineers and the National Electric Light Association. A native ability for leadership is reinforced by a ready mastery of principles and problems, an epigrammatic eloquence, and a buoyant temperament, such a combination as would carry any man far in his chosen field.



FARLEY OSGOOD

Born at Boston, Mass., April 5, 1874, Farley Osgood, when only 23, graduated from the Massachusetts Institute of Technology in the class of 1897; and as the American Bell Telephone & Telegraph Company was then systematically "mopping up" all the electrical graduat-

ing classes, the new E. E. found his way naturally into telephony, making advances rapidly in the technical hierarchy. But the handling of "big currents" made more appeal to his own robust nature, and he found even more congenial employment with the New Milford, Conn., Power Company, 1903-7. Then he stepped easily into the organization of the Public Service Electric Company of Newark, N. J., in 1907, and since April 1, 1917, he has been vice-president and general manager of the great public utility supplying light and power to the millions of people and much of the State of New Jersey. Propinquity to New York has enabled him to give invaluable co-operation on committees, and in other ways, in dealing with leading electrical and other problems of the day; and his driving power may be gauged by the brilliant success attendant on his work in organizing the joint meetings of the four national engineering societies, when as has been said: "American engineering has now founded a professional forum of its own." These meetings are held in New York City.

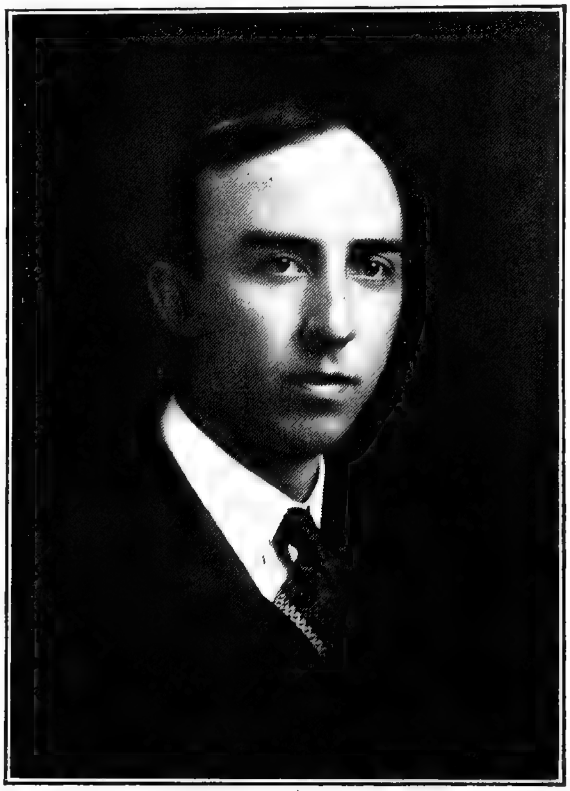
Mr. Osgood is a member and officer of the American Institute of Electrical Engineers; and a member also of the National Electric Light Association, the New York Electrical Society, and the Sigma Chi Fraternity. He is also a member of the Engineers' and Technology clubs of New York City, the Essex and Union clubs of Newark, the Essex County Club, and the Orange Lawn Tennis Club of West Orange, N. J.

BERT H. PECK

Bert H. Peck, who since 1919 has been General Manager of the Southern Illinois Light and Power Company, with offices in the Central National Bank Building, St. Louis, Missouri, has had a varied experience in public utility fields. Mr. Peck was born in Berlin, Wisconsin, February 23, 1885, and completed his common school education in that city. In 1906 he graduated from the University of Wisconsin with the degree of B.S. in E.E. While attending college he was elected a member of the honorary engineering fraternity of Tau Beta Pi, and in 1916 received the professional degree of E.E. from the same institution.

Soon after graduation he entered the engineering department of the Chicago Telephone Company, and from 1907 to 1914 was connected with the consulting engineering firm of D. C. and Wm. B. Jackson. In this position he was engaged on several investigations of national importance, including a complete analysis of the affairs of the Chicago Telephone Company.

In 1914 he became telephone expert for the city of Chicago and, after organizing that work, for five years held the position of chief electrical engineer of the Public Utilities Commission of Illinois.



BERT H. PECK

The Southern Illinois Light and Power Company is engaged in rendering electric, gas, water, heating and street railway ser-

vice over a wide territory in the central and southern part of Illinois and also in the manufacture of ice. In 1917 Mr. Peck received the Octave Chanute Medal from the Western Society of Engineers of which he has been a member for many years. He is also a member of the American Institute of Electric Engineers; the Springfield, Illinois Engineer's Club and of the St. Louis Electric Board of Trade.

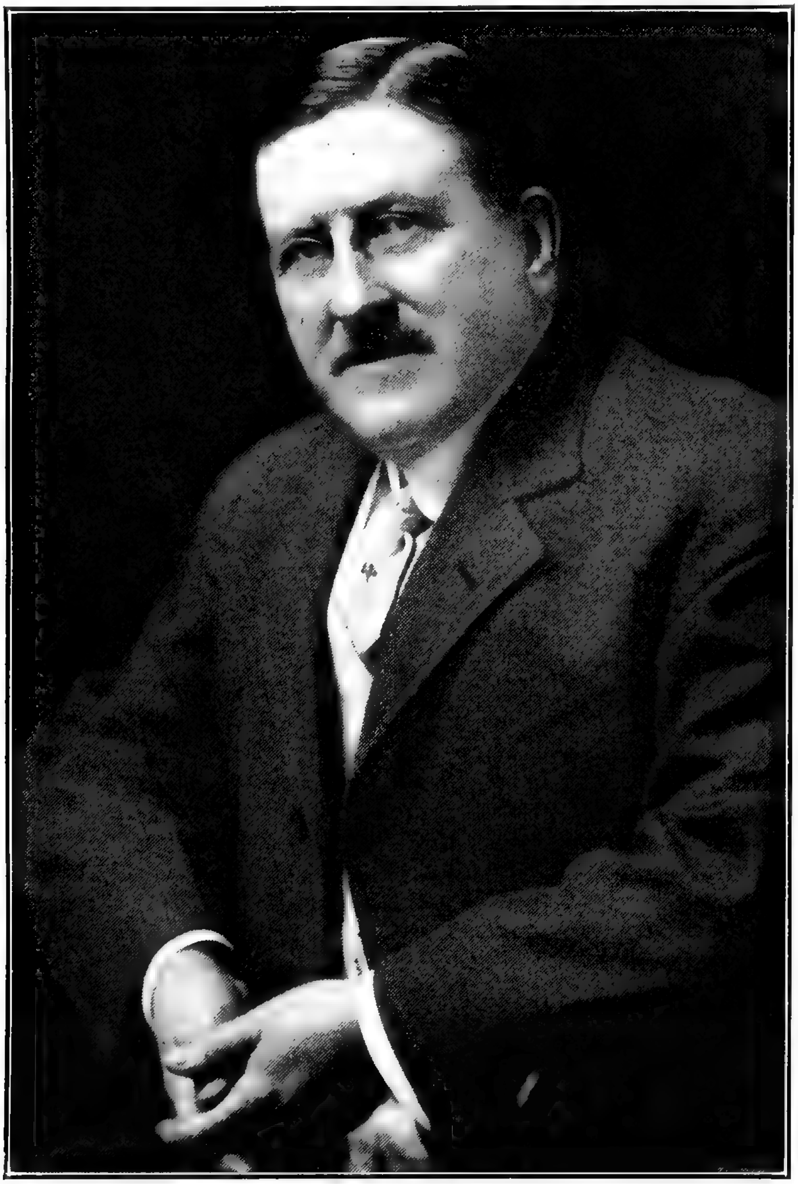
HEMAN J. PETTENGILL

Telegraphy may well be called the Mother Country of the modern electrical engineer. From it have proceeded by units and swarms a very large proportion of the men to be found not only in all branches of industry but particularly in the various departments of applied electricity. Even today when the schools and colleges are turning out literal droves of electrical graduates, the plain, ordinary telegrapher still holds his own, rather like the original Anglo-Saxon stock in America; and is not swamped or snowed under. The training at the key for any intelligent, observant youth may not be quite the equivalent of a university course in book knowledge, but it has certainly evidenced its ability to sharpen wits already acute and to shape many notable careers. We need not pause on such world renowned celebrities as Edison and Carnegie, for even a most casual glance or inquiry will bring to view illustrious names made by men who began as simple operators or, even better, as messenger boys. As already noted elsewhere in this story a very brief list would include such men as Daniel Lamont, Secretary of State under Cleveland, or Marshall Jewell, Postmaster General under Grant. As Governors of their respective States were Cornell of New York and Rufus Bullock of Georgia. Amongst publishers, let there be noted Frank A. Munsey of "New York Herald" and many magazines, or W. J. Elverson of the "Philadelphia Inquirer," or Edward Rosewater of the "Omaha Bee," or W. J. Johnston founder of the "Electrical World." George Kennan is universally known as a writer; Guy Carleton wrote brilliant plays. Among Presidents of great railroads were W. C. Brown of the New York Central and Marvin Hewitt of the Chicago and Northwestern. Gen. T. T. Eckert was not only president of the Western Union Telegraph in his prime, but in his youth was Lincoln's real "live wire" as Assistant Secretary of War. Other notable men have been Theodore N. Vail, literal father of the Bell Telephone System, one of the world's great organizers; A. B. Chandler, president of the Postal Telegraph & Cable Company, D. H. Bates, president of the Baltimore & Ohio Telegraph System, R. C. Clowry, president of the Western Union Telegraph, L. C. Weir, president of Adams Express, Thomas Ahearn, "utility king" of Ottawa, Canada; R. U. Johnson, once editor of the "Century Magazine" and later U. S. Ambassador to Italy.

An additional entry in this group is Heman J. Pettengill of St. Louis, who was born April 8, 1851, at Brunswick, Me., educated in the public schools there, and at the age of 15 began his business life as a messenger for the old American Telegraph Company at Brunswick. He soon became a "brass pounder," and about 1870 entered the employ of the Western Union Telegraph Company at Boston. He tells the following story of those early days:—"Thomas A. Edison was employed there in the same capacity and resigned his position about the same month I entered the service. I remember what was said to be the first invention of Edison. He was employed on the night force. All the operators brought their lunches, which were placed on a table in the operating room, a place overrun by cockroaches. Edison pasted strips of tinfoil taken from John Anderson's packages of chewing tobacco around the edges of the table, and connected the strips with a battery, so that when the roaches attempted to reach the food in the middle of the table their legs were burned off. The lunches were thus preserved in good condition."

Mr. Pettengill was with the Boston

Western Union office as operator, chief operator and manager 1867-1880. He was manager of the American Rapid Telegraph Company, Boston, 1880-2, and then entered the management of the Northwestern Telephone Exchange Company, as vice-president and president 1899-1905, and was vice-president and president of



HEMAN J. PETTENGILL

with the Bankers & Merchants Company, United Telegraph Company, and Postal Telegraph Company as manager and superintendent, 1882-1899. He now made an easy transition to the telephone field, and was associated with the Cleveland Telephone Company and Wisconsin Telephone Company 1899-1905. He also en- the Southwestern Telegraph & Telephone Company 1899-1919. In 1912 he became president of the latter company and is now the chairman of the board of the Southwestern Bell Telephone Company. A highly typical and representative career.

Mr. Pettengill is a direct descendant from John Alden, Francis Cooke and

George Soulé, who came over in the little "Mayflower" in 1620. All three signed its famous Compact. Richard Pettengill followed them from England in 1632, and settled in Salem, Massachusetts. Needless to say that the present Pettengill is a member of the Society of Mayflower descendants and of the Sons of the American Revolution. He is also a Governor of the Society of Colonial Wars in Missouri; Missouri Chairman of the League to Enforce Peace; director of St. Louis Chapter, American Red Cross; trustee, St. Louis Home & Housing Association; and vestryman of St. Peter's Episcopal Church, St. Louis.

Mr. Pettengill is also a member of the American Institute of Electrical Engineers, Telephone Pioneers of America, Old Time Telegraphers' Association, and the Academy of Political Science. His clubs are the Commercial of St. Louis, the St. Louis Club, St. Louis Country Club, Noonday Club of St. Louis, Bellerive Country Club, St. Louis, the City Club of Dallas, Tex., and the Dallas Country Club. His office is in the Boatmen's Bank Building, St. Louis.

CENTURY ELECTRIC COMPANY AND ITS PRESIDENT, MR. EDWIN S. PILLSBURY

Another great manufacturing plant that has made of St. Louis a distinctive electrical center, and has added to the reputation of the mid-western municipality as the home of substantial, honest products, is the Century Electric Company located in the district centering around and about Nineteenth, Pine and Olive Streets of that city.

"Century" products are familiar to electrical men; the name stands for integrity in the field, and the success which the company has attained during the nearly two decades of its existence, makes the story of especial interest to those who delight in following the careers of those who have won their way into the front ranks.

Perhaps the first thing to be noted is the physical side of the plant. Could the ten buildings of which it consists, and which are scattered over an area of two or three blocks, be gathered into one structure and under one over-spreading roof, its size and importance would be more impressive to the casual observer. The floor space is there, however separated, and the company gives employment to at least one thousand expert mechanics in the manufacture of machines which find a market over the entire world.

Before entering more fully into the details of this widely known enterprise let us consider the element which has been strongest in its development.

The Century Company was born for a purpose, lived up to the ideals of its inception and found success as planned. This may be attributed to its management—while management may be the vital spark in all concerns—it is particularly true of the Century Company. The president of the company, for instance, is a man whose name means much in the electrical field. He represents that rare combination of an inventive mind, and a keen, commercial, business instinct. Mr. Edwin S. Pillsbury is known first to electrical men as the developer of the successful repulsion start, induction operating, alternating current motor, and second as the president of this company. Through his patience in research and acumen in business, St. Louis leads all the world today in the production of this class of motor. Mr. Pillsbury inherits his qualifications from an ancestry born and bred in that rock-ribbed New England section from which so many of the leaders of

EDWIN S. PILLSBURY

the mid-Western Americans have their origin. The struggle, on which those forefathers erected their lives, built up characters of granite like the soil from which they fed. While, by accident Mr. Pillsbury missed being born in New England, his parents returned to those parts before he had hardly grown from pinafores, and his youth was passed in the atmosphere and influence of the New Hampshire hills.

Mr. Pillsbury was born in Riley County, Kansas, January 12, 1867, where his parents, Leonard H., and Evelyn (Sanborn) Pillsbury were for a time residing. Both his parents were representatives of old New England families and both had been born and reared in New Hampshire state. The Pillsbury family traces its American ancestry back to 1683 when members landed on these shores from England. One branch of the family has been conspicuous in the Northwest in both milling and political circles.

The Sanborn family, from which Mr. Pillsbury's mother came, is also of English origin and was one of the early families to adventure into the new world of America.

After residing for a time in Memphis, Tennessee, where Mr. Pillsbury's father was an officer of the United States Court, the family returned to New Hampshire; a rare circumstance in those days as travel was mostly West.

The elder Mr. Pillsbury was captain of a New Hampshire company during the Civil War, a company which he himself recruited in his native State, and was engaged in a number of the most important battles of that conflict, including the campaign against Vicksburg where his original company of over one hundred was reduced to only nine able to answer at roll call. Mr. Pillsbury, senior, has served his State in the Legislature more than once and, in fact, is now a member of that body although eighty-five years of age.

Edwin S. Pillsbury, of the Century Company, was educated in the public schools, in Pinkerton Academy, Derry, New Hampshire and the Massachusetts Institute of Technology, laying a firm foundation for the work which he was destined to do in the world. In 1894 the Emerson Electric Manufacturing Company of St. Louis entered into a contract with Mr. Pillsbury to go to that city and develop a single phase, alternating current motor which to that date had not proven a success commercially. From that time on his position in the electrical world has been known and followed by those familiar with the industry and today St. Louis leads the world in production of this type of motor.

The Century Electric Company was organized in 1904, or rather it took the name in that year, growing out of the H. E. Lindsey Electric Supply Company which Mr. Pillsbury had joined some two years previously.

Mr. Pillsbury has had control of the company from the first and was elected its president in 1913. It is capitalized at $1,750,000, and the plant is a model working machine. Buildings have been added from time to time as the business grew and is now a prominent feature in the city's manufacturing life, with branch sales offices in some thirty other cities in this country. The product of the Century works consists of:

Repulsion start induction constant speed singlephase motors which are built in standard sizes ranging from 1/10 to 40 horsepower—this is the main product of the works; automatic start induction polyphase motors, 1/2 to 60 horsepower, a motor which develops a high starting torque with low starting current without an external starting device; squirrel cage polyphase motors with a welded conductor rotor that is indestructible in service; split phase motors, 1/4 horsepower and smaller; and alternating current fans, 9, 12 and 16 inch sizes in stationary and oscillating type, and an alternating current ceiling fan.

A line of goods in which there is an inherent margin permitting of satisfaction under a reasonable variation from normal loads and operating conditions, a definite effort to protect the reputation of the goods by a conservative sales engineering policy, and a commercial organization thoroughly imbued with the progressive century spirit, have caused the company's products to be well and favorably known among the trade throughout the greater part of the world.

This is something of the business that Mr. Pillsbury and his associates have erected during the past twenty years. Mr. Pillsbury is very democratic in all his relations and his employees realize they have a personal friend in their president.

Aside from the pecuniary rewards which naturally came with such work, three sons have been given to Mr. Pillsbury and his wife since their marriage in 1907.

Mr. Pillsbury is a member of the A.I.E.E., president of the Missouri Baptist Sanitarium and a trustee of William Jewell College of Liberty, Mo.

W. EDGAR REED

W. Edgar Reed is a representative of the later group of electrical "arrivals" who are making fame and fortune in connection with the development of the great modern electrical industries associated with electro-metallurgy and electro-chemistry. Born April 15, 1875, at Belleville, Ohio, he was graduated from the Massachusetts Institute of Technology, 1897, and then took a post-graduate course in the laboratory of Prof. Henri Moissan, in Paris, France, where the very spectacular work was done of making, electrically, minute diamonds, and research work at very high and low temperatures, attracting the attention of the whole world, and leading to many of the later developments in the electrical arts and sciences. Mr. Reed then began his active business career as a designing engineer with the Société Anonyme Westinghouse (French Westinghouse Company) in November, 1898, going to the new shops at Havre, where he came under the influence of another great man, Albert Schmid, the Swiss electrical designer, with a wonderful sense of beauty and proportion in all his machines. Mr. Reed was ripe and ready, having already had the student Westinghouse course in the U. S. A., from 1891 to 1893, and during summer vacations 1893-7. At first inclined to follow in his father's footsteps as a physician, the promising future of electricity, acquaintance with the pregnant inventions of Tesla and others, and the helpful suggestions of Schmid made him definitely an electrical engineer.

Mr. Reed became the chief electrical engineer of the French Westinghouse Company in charge of design, construction and testing of all the apparatus it constructed, and then he transferred his energies in a similar way to the service of the American company. He continued in such a capacity until 1907, when he became consulting engineer for various companies, especially those growing up under the new régime; and doing notable work in the invasion of the chemical field, as electricity had earlier invaded and captured so many others. His experience with Moissan gave Mr. Reed advantages then hardly to be equalled in America, and he was prompt to seize the opportunities presented. Much of the formative work of the new period and many of the results may be ascribed to Mr. Reed's special training and ability as an electro-chemist.

The bent of Mr. Reed's disposition and devotion in this difficult new territory are perhaps best illustrated by the fact that he is director, secretary and assistant treasurer of the American Refractories Company and a director of the Concordia Electric Company. He is, or has been, however, consulting engineer for several American cities, and does consulting work for steel mills, coal mines and a number of various industrial corporations.

Mr. Reed's father was a physician and surgeon in the Civil War and was attached to the One Hundred and Fifteenth Ohio Volunteers. His grandfather was of Pennsylvania Dutch origin, so that it is perhaps not at all unnatural that he should make himself very much at home in Pittsburgh as a center for professional work.

He is a Fellow of the American Institute of Electrical Engineers, and a member of the Engineers Society of Western Pennsylvania. He is also a member of the Pittsburgh Golf Club, the Pittsburgh Country Club, and the Pittsburgh Athletic Club. As a student, particularly in the novel lines of research that have been indicated, Mr. Reed has been called upon for

W. EDGAR REED

much research and laborious investigations, but he is swift to admit that in his professional work he has ever found much aid in the progressive journals of electrical engineering—the *Electrical World*, the *Electrical Journal*, and the *Electric Railway Journal*. But he is fond of referring to the strong impress made on his life and career by close association with the little appreciated genius—Albert Schmid—upon whose advice such a great inventor as George Westinghouse was glad to lean heavily in all his electrical and mechanical enterprises.

FREDERICK SARGENT

The late Frederick Sargent at the time of his death, July 26, 1919, at his home in Glencoe, Illinois, was undoubtedly the most prominent and successful engineer in the United States specializing in central station design and the titanic power development associated therewith. His career was one of unusual international interest. Born at Liskeard, Cornwall, November 11, 1859, he came to the United States in 1880, with a great natural aptitude for mechanics and engineering, trained and developed in those matchless schools, the shipbuilding yards of Glasgow; and his mathematical mind sharpened further by studies at Glasgow University.

It was only natural that his initial American employment was as a mechanical designer for Neaffle and Levy, ship builders, Philadelphia. Next he entered into general engine design and engineering work, first on the Atlantic Seaboard and then in the middle west at Sioux City, Iowa, as well as later with E. P. Allis & Co., predecessors of the Allis-Chalmers Manufacturing Company, Milwaukee. At this point came the next vital event in Mr. Sargent's career, for his skill and work attracted the attention of the Western Edison Light Company, just established at Chicago, to introduce the Edison Incandescent Lighting System; and in the Fall of 1884 he went to that city and began his life work as an electrical engineer.

It will be seen that with his already unusually fine experience in marine engine design, Mr. Sargent was an ideal man to be enlisted by the new art of electric light and power, which presented novel opportunities and problems for his attention. The direct outcome of the Western Edison Company was the Chicago Edison Company, founded in 1887, whose original Edison central station he built soon after, 1887-8, at West Adams Street, where to this day Edison has maintained and strengthened his chief western foothold. In 1892, the young enterprise called aloud for more leadership, and Mr. Samuel Insull went to Chicago to furnish it. Up to that time Mr. Insull had been known chiefly in the electrical manufacturing field, but, convinced that the biggest sphere was that of central station supply, he selected Chicago as a fitting arena for his talents and ambition. Thus Sargent and Insull came together to do their great pioneer constructive work and to leave forever a deep imprint for good on the central station industry not only of the United States but of the world.

One of Mr. Sargent's notable merits was that in spite of a natural British conservatism, he was not only curiously receptive of new ideas but startlingly ready to try them out in his own practice. As consulting electrical engineer for the World's Columbian Exposition at Chicago, he designed its great power plant, introduced various novel features and summed up brilliant progress to that date. He was one of the very first of the great engineers to see that the steam turbine was already challenging the supremacy of the splendid reciprocating steam engines of the time; and with the enthusiastic support of Mr. Insull, while all America looked on in suspense, he carried out ideas and plans which made the steam turbine the very foundation of modern central station engineering. In his Chicago Edison plants he went with never-failing courage from magnitude to magnitude, from higher to higher pressures, from refinement to closer

refinement, from economy to economy, until, as was once said: "When it comes to generating electric power economically and cheaply, Sargent has got Niagara beaten to a finish."

Not only were Mr. Sargent's abilities displayed in the great Harrison, Fisk and Quarry and Northwest generating stations of the Commonwealth Edison Company at Chicago, but his services were in demand all over the country for such corporations as the Edison Electric Illuminating Company of Boston; American Gas & Electric Company; Union Gas & Electric Company, Cincinnati; the Kansas City Light & Power Company, and many others. One of his latest monuments is the great combined power plant, built under West Penn Company and American Gas & Electric Company auspices near Wheeling, W. Va., on the Ohio River, which is the first large plant built in a favorable coal mine locality, close to the pit mouth, for the generation and supply of electrical energy at long range to industrial centers. At one time Mr. Sargent was sent to London as a representative of the United States at the hearings in Parliament in connection with the proposed legislation for the unification of power supply in the English metropolitan area. In 1916, he was sent to Chile as a consulting engineer for the Guggenheim mining interests to arrange the development of a power supply for their mine properties at Chuquicamata. All this and much other work was supplemented during the Great War, when Mr. Sargent became consulting engineer for the U. S. Government on various large-scale power projects and for the power station at the Edgewood Arsenal, Maryland. He gave his best ability to this patriotic work.

To all these responsible undertakings, Mr. Sargent brought qualities of the highest value. As was said by an intimate associate, Mr. W. S. Monroe: "He had an exceptionally keen and active intellect, and a vigorous and forceful personality. He was a man of absolute integrity and fearless independence and high idealism in his work. He had an infallible intuition regarding engineering and scientific matters, and the responsible men in the companies for which he was doing his engineering learned to place the utmost confidence in his judgment. He had a remarkable combination of extreme daring and careful conservatism. With a broad and ambitious view of important and fundamental principles of his engineering work, Mr. Sargent combined an accurate knowledge of all the underlying details; and no detail was too small for his personal attention. He kept in close touch with everything new in the engineering profession. He was a great traveler and made repeated trips to Europe as well as through this country in order to post himself on the important developments, not only in the direct line of his own work but in all departments of the engineering field."

It was indeed to one of these trips that Mr. Sargent may be said to owe his last illness, for he was taken seriously ill abroad, and on his return from Europe went under medical treatment at home and hospital. But at sixty years of age he was not able to endure fatigue and disease that in earlier years his sturdy, robust physique would have withstood easily, and which had enabled him in his private practice or as senior partner of the firm of Sargent & Lundy, formed in 1891, to carry out the really stupendous feats of engineering with which his memory will always be closely associated.

Mr. Sargent was awarded a gold medal for the work he did at the Chicago World's Fair in 1893. He served as a member of the jury of awards of power engineering at the St. Louis Exposition of 1904. He was not a "club man" in the strict sense of the phrase, but enjoyed social life keenly and was a member of a great many societies and clubs, among which may be mentioned the American Society of Mechanical Engineers, Western Society of Engineers, University Club, the Engineers' Club of New York, Chicago Yacht Club, and the Skokie Country Club.

Mr. Sargent was married in 1885 to Miss Laura S. Sleep, daughter of William H. Sleep, manufacturer of agricultural implements of Plymouth, England, who survives him, with one daughter, Miss Dorothy E. Sargent, and two sons, Chester and Ralph.

It would seem fitting to close this brief biographical sketch with a eulogy on Mr.

FREDERICK SARGENT
(DECEASED)

Sargent uttered in 1911 when much of his best work was still to be done, by his friend and colleague in great work, Mr. Samuel Insull, who spoke of him as "at the head of his profession, the electrical engineering profession, in this community, and the designer of our wonderfully economical central stations."

FRANK L. SESSIONS

FRANK L. SESSIONS

All the good men from down East did not settle in the Western Reserve at the first remove. They have been going there ever since the great hegira which Cleveland celebrated in its own case with so much éclat and enthusiasm in 1921. An example is Mr. Frank L. Sessions, born at Hampden, Mass., September 27,

1868, educated at Worcester Polytechnic Institute, graduated in 1889, and granted the degree of M.E. in 1909, being also a member of the Sigma Xi.

Proceeding promptly to the scene of his future labors, Mr. Sessions became, first, machinist, inspector and draughtsman with the Deane Steam Pump Company; but soon directed his steps to the electrical field. With the Fort Wayne Electric Company he was draughtsman and chief draughtsman and mechanical and electrical engineer. Then with the Siemens-Halske Electric Company of America he was mechanical engineer in charge of design. The Brown Hoisting and Conveying Machine Company next enjoyed his services as mechanical and electrical engineer. He was next with the Jeffrey Manufacturing Company as chief engineer, and next he became general superintendent and mechanical and electrical engineer with the Standard Welding Company. Since 1913 he has practiced as an independent consulting engineer and mechanical and electrical expert, there being many calls for his valuable service in patent and other causes and in the development and patenting of inventions in the large field with which he is so familiar.

Mr. Sessions is himself the inventor and patentee of upwards of eighty inventions in his chosen field of work—the electrical and mechanical arts. They include electric mine haulage locomotives; electric gathering locomotives to replace the festive mule in mines; storage battery locomotives; electrical generators and motors; switches, circuit breakers, clutches, controllers, resistances, etc.; welding machines, methods of welding, systems of electrical distribution and control, coal-mining machines, vehicle wheel rim machinery, automotive machinery and appliances, and other kindred improvements and innovations.

Mr. Sessions is a member of the Sons of the American Revolution, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Cleveland Engineering Society, the Electrical League, the Rotary Club, the Clifton Club, and the Westwood Country Club. He is president of the Board of Education of Lakewood, Ohio, and is deeply interested in education. He turns to golf for recreation and pastime.

C. H. SHEPHERD

Although a native of Texas, C. H. Shepherd has always been closely identified with the electrical developments of the Middle West. His ancestry carries him back on his father's side to the Ball and Washington families of Virginia, and on his mother's side to the Barnhart and Ellington families of Maryland, including later the Haydons, pioneers in the development of Illinois.

Born May 17th, 1886, at Palestine, Texas, he studied at the University of Arkansas and later at the University of Wisconsin, where he was graduated in 1908, his college fraternity being Sigma Chi. After graduation in electrical engineering he was student engineer at the Allis-Chalmers Company, Norwood, Ohio, and went from there to the Commonwealth Edison Company as electrical operator and was at the Fisk Street station during the first great reconstruction period. From there he went to the Commissioners of Lincoln Park as chief electrical operator and later as operating engineer. From this position he went with the Department of Gas & Electricity, City of Chicago as special construction inspector and was later promoted to chief layout engineer in charge of design, engineering, and ultimate supervision of construction on the municipal street lighting system. He resigned from this position to become Electrical Engineer in charge for the Commissioners of Lincoln Park and while there rebuilt the entire electrical, water and motor transportation system. During this period he was instrumental in the development of the series-multiple transformer for street lighting which resulted in Lincoln

Park having the first extensive installation of this character in the United States.

In 1920 he went with the Bemis Company of Chicago as chief engineer in charge of the valuation of the St. Paul railway system and various other properties and in 1921 resigned from this company to enter private practice as Consulting Engineer in street lighting and general power system engineering and has since designed some extensive installations of various kinds. He has always been interested in thermo-dynamics, radio transmission, motor transportation, business economics and astronomy.

C. H. SHEPHERD

C. H. Shepherd is a member of the American Institute of Electrical Engineers, the Western Association of Inspectors, Kiwanis Club, Brotherhood Lodge No. 986, A. F. & A. M. Lincoln Park Chapter No. 177, R. A. M. and Humboldt Park Commandery, No. 79 Knights Templars.

BARTON R. SHOVER

Barton R. Shover, born February 13, 1868, at Dublin, Indiana, is a westerner, whose paternal and maternal ancestors alike were pioneer settlers in the Western Reserve prior to the admission of Ohio and Indiana as States of the Union; and

BARTON R. SHOVER

the fortunes of the family have therefore been closely identified with that region. He graduated from the Rose Polytechnic Institute of Terre Haute, in 1890, received the M. S. degree in 1895; and in 1917 the E. E. was conferred upon him by his Alma Mater, not for a submitted thesis but upon his professional record. Immediately after receiving his sheepskin, he began in July, 1890, experimenting, designing and testing electrical heating devices for the pioneer Carpenter-Nevins Electro Heating Company of Minneapolis, and after that broke into the street railway field. He did power house and line construction work for the Indianapolis Street Railway Company, and for the Richmond, Ind., Street Railway Company; became also assistant superintendent of the Sea Shore Electric Railway Company of Asbury Park, N. J., and chief electrician of the Youngstown, O., Street Railway.

After putting in about five years at such work, impressed with the great possibilities in the then comparatively undeveloped electrification of the steel industry, he threw his fortunes into that ring, and helped make history, as chief electrician of the Ohio Steel Company of Youngstown, O., electrical engineer of the Indian Steel Company, Gary, Ind., electrical engineer Carnegie Steel Company, Youngstown District; general superintendent Brier Hill Steel Company, and general manager of the Tata Iron & Steel Company, Sakchi, India. At the time this sketch was prepared he was engaged in business as a consulting engineer and among other work was installing a 110-inch motor driven plate mill for the Dominion Iron and Steel Company of Canada, building a new power plant and electrifying all their existing mills; as well as building a power station and electrifying their iron ore mines at Wabana, Bell Island, Newfoundland, and their coal mines at Glace Bay, N. S. He was also acting as consulting engineer for The Electric Alloy Steel Company of Youngstown, O., in building extensive works for the manufacture of the highest grades of steel, and whose entire works, including the steel furnaces are to be operated electrically. It may be noted that the famous Gary plant was the first complete electrically driven steel mill in the world, depending moreover on gas engines for prime power and the gas itself coming from the blast furnaces.

Mr. Shover is a past president of the Association of Iron & Steel Electrical Engineers, as well as a Fellow of the American Institute of Electrical Engineers, and a member of the American Iron and Steel Institute. He is a member of the Union and Duquesne clubs of Pittsburgh, and the Pittsburgh Athletic Association. He also belongs to Al Koren Temple, A. A. O. N. M. S. of Cleveland, Ohio.

Mr. Shover has said:—"Civilization owes its rapid advancement largely to the steel industry, and without the application of electric power, that industry could not possibly have reached its present state."

EUGENE J. SPENCER

GEN. EUGENE JACCARD SPENCER

Some day a separate book will have to be written on the remarkable work done in the development of the modern electrical field by men trained for the Army and Navy to whom, in the "piping times of peace," the opportunity it afforded for the exercise of their energies and abilities proved quite irresistible. The list is a long and notable one of distinguished names to be thus embraced. Among such men may be noted Col. Eugene J. Spencer, U. S. A., whose interest in military affairs may well be traced back, if no further, to a great-grandfather who was one of the famous Revolutionary "Green Mountain Boys," and a grandfather who was commander of the First Michigan Cavalry, in the march from Detroit to Chicago and in the Black Hawk Indian War. Born at St. Louis, Mo., July 31, 1859, Col. Spencer was educated in the public and high school of that city, and then proceeded on appointment to the U. S. Military Academy at West Point, from which he graduated with distinction in 1882. His further studies were in the Engineer Officers' School of Application. After service against hostile Apache Indians under Geronimo, there being no prospect for further active service, he resigned from the Corps of Engineers to take charge of putting underground the wires of the companies in New York City in which the Thomson-Houston Electric Company had "parent" interests. He then went to the Thomson-Houston factory at Lynn, Mass., in charge of the supply department, and organized the testing department which afterwards developed into that of research. He was very much at home in electrical work, having when at West Point been in close contact with Lieut. Oscar T. Crosby, as well as an instructor in chemistry and electricity. Through Crosby he met both Frank J. Sprague and Dana S. Greene, then beginning their remarkable work in New York City. In 1892-3-4, Lt. Spencer, as he then was known, was in full charge of the splendid General Electric exhibit at the Chicago-Columbian Exposition, including the historical first electric American elevated road around the grounds.

Resigning from this connection in 1894, Lt. Spencer located in St. Louis, having many calls for his services; being Western representative of the Lake Erie Engineering Works, and until 1904 Western representative of the Safety Insulated Wire & Cable Company. He has also been a consulting engineer and adviser to the street railway interests, as in St. Louis, Granite City, and Alton, Ill., Paris and Texarkana, Tex.

In 1898, during the excitement over the Spanish War, Lt. Spencer returned to military service as Lt.-Col. of the Third Regiment of the U. S. Volunteer Engineers. When, under National legislation the State Military organizations were incorporated into National defense plans, he was, July 5, 1906, commissioned as Colonel of the First Regiment of Infantry, N. G. of Missouri. He raised the money amongst the business interests of his native city to buy the land and build the present Armory of that organization. On Feb. 18, 1913, he became Brigadier General of the National Guard of Missouri.

For the third time he entered military service when the Great War broke out, and on December 20, 1917, he became Colonel of the Thirty-second Regiment, U. S. Engineers (standard-gauge railroad and bridge construction); was Chief of Staff, Base Section No. 2, A. E. F., and later Section Engineer of the same. In 1919 he was decorated by the French with the cross of an Officer of the Legion of Honor.

General Spencer has also been very active and prominent in a number of social and military organizations. He is a past president of the St. Louis Chapter of the Sons of the American Revolution; past president of the Engineers' Club of St. Louis; past commander of the Missouri Commandery Military Order of Foreign Wars of the U. S.; twice president of the Mercantile Club of St. Louis; a member of the American Institute of Electrical Engineers; and the American Academy of

Sciences; member of the Missouri Athletic Association, and last but not least, president of the St. Louis Association of West Pointers, and a member of the American Association of Military Engineers.

General Spencer is now the manager of the St. Louis Electrical Board of Trade, Arcade Building, St. Louis, with residence at 215 Oakwood Avenue, Webster Groves, Mo.

BERNARD E. SUNNY

Bernard E. Sunny, president of the Illinois Bell Telephone Company and of the Wisconsin Telephone Company, was born in Brooklyn, N. Y., May 22, 1856. His father was Bernard Sunny and his mother, Margaret E. Sunny.

Mr. Sunny was educated in Brooklyn, N. Y., and has an honorary degree, Doctor of Engineering, conferred by Armour Institute, Chicago.

Mr. Sunny began his business career in 1872, as a messenger in the employ of the Atlantic and Pacific Telegraph Company, later becoming an operator. In 1875 he went to Chicago, there continuing in the employ of the Telegraph Company he had served in the East, and he soon became night manager of the office, and was later advanced to the position of manager.

The telephone, then in its infancy, attracted his attention. In 1879 he was offered the superintendency of the Bell Telephone Company, and resigned from the telegraph to enter this new field of electrical transmission. In the subsequent merger of the Bell and Edison companies, thus forming the Chicago Telephone Company, Mr. Sunny continued to hold the superintendency. He remained identified with the telephone interests until 1888 and was closely associated with the first successful efforts to operate telephone wires underground.

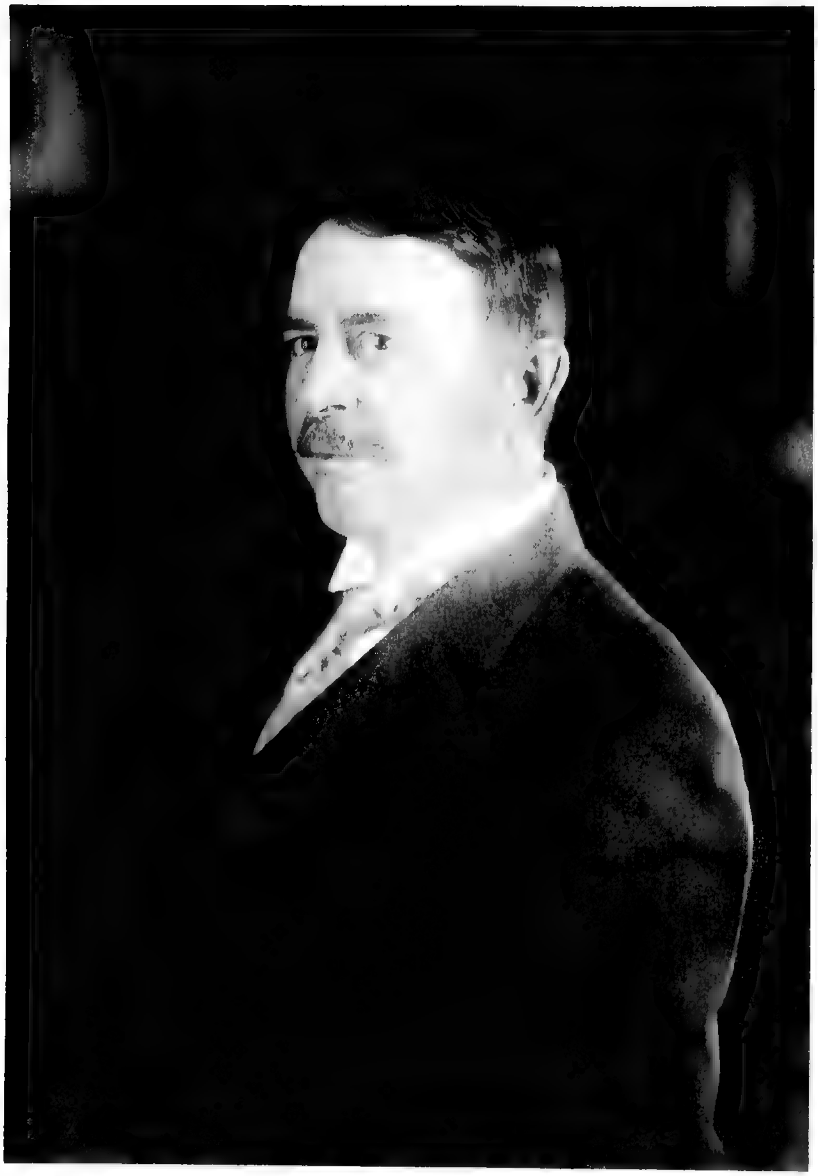
In 1888 Mr. Sunny became President of the Chicago Arc Light & Power Company, which position he retained for two years. His next change was to accept the Western management, with headquarters at Chicago, of the Thomson-Houston Electric Company, and in that responsible post he remained for another two years, achieving much to advance the interests of that corporation in the Western field. When the organization of the General Electric Company was brought about through the merging of the Thomson-Houston, the Brush and the Edison General Electric companies, Mr. Sunny was called to manage its Western interests. He was made a vice-president of the General Electric Company in 1906.

Mr. Sunny was interested in an important way in the development of the street railway and central station lighting properties in the Middle West, not only on behalf of the General Electric Company but personally. He was the principal owner and executive in the Central Power Company which now supplies electric power and light throughout Central Nebraska. He was active in the development of the street railway business in Topeka, Kansas, and in similar work in other western cities.

In 1908 Mr. Sunny resigned his position with the General Electric Company and went back to the telephone service, after an absence of twenty years, as vice-president of the American Telephone & Telegraph Company and President of the Chicago Telephone Company. In addition to the above offices, he was also made President of the Central Union Telephone Company, Michigan State Telephone Company, Cleveland Telephone Company and Wisconsin Telephone Company.

Mr. Sunny is a Director in the First National Bank, the First Trust & Savings Bank, the National Safe Deposit Company, the General Electric Company, the Chicago City Railway Company, the Chicago City & Connecting Railways, the Public Securities Corporation, The Hurley Machine Co., Victor X-ray Corporation, Hill, Joiner & Co., Ironwood & Bessemer Ry. & Light Co., and the Edison Electric Appliance Company.

He is chairman of the board of trustees of Central Church, Chicago; a Fellow in the American Institute of Electrical Engineers; member of the Western Society of



BERNARD E. SUNNY

HOWARD F. THURBER

Engineers; member of the Art Institute of Chicago and of the Chicago Historical Society and president of the Old Time Telegraphers Association.

He is a member of the Commercial Club of Chicago, and was its president 1914-15, the Chicago Club, the Union League Club, the Mid-Day Club, the Hamilton Club, the Traffic Club, the Glen View Club, the South Shore Country Club and of the Flossmoor Country Club.

Mr. Sunny has always taken an active interest in civic and political affairs. He was president of the Civic Federation of Chicago for four years, and effected the successful campaign for an amendment to the constitution of the State which gave Chicago its splendid municipal court in place of the disreputable justice court system which prevailed for many years, and which will also permit the city of Chicago to secure a much needed new charter whenever the latter can be agreed upon.

He was one of the organizers of the National Citizen League for the Promotion of a Sound Banking System, and which resulted in the creation of the Federal Reserve Banking System.

He was appointed president of the Police Pension Fund by a Democratic mayor, served for four years, and later was appointed by a Republican Governor as president of the Board of Trustees of the Eastern Illinois Hospital for the Insane, which position he filled for a similar period. He served for three years as a member of the Visitation Committee of the Juvenile Court; he was a commissioner to select the site for the State Home for Delinquent and Dependent Boys, appointed by Governor Yates; he was also a trustee of the Illinois Manual Training School for Boys, Glenwood, Illinois. He was appointed by Governor Yates and served one year, as trustee of the School for Delinquent Girls, Geneva, Illinois.

HOWARD FORD THURBER

Howard Ford Thurber, born in Brooklyn, N. Y., August 6, 1869, was educated first at the Polytechnic Institute there and then proceeded to Cornell University, where he graduated in 1890 with the degree of M. E. He heard a lecture by Dr. Alexander Graham Bell, the inventor of the telephone, while at Cornell, and the references to the development of that instrument impressed him greatly. On graduation he at once sought and secured a position with the old Metropolitan Telephone and Telegraph Company, in the Engineering Department of that predecessor of the present New York Telephone Company. At that time there were but 6000 telephone stations installed in the territory covered. Today Mr. Thurber has a great deal to do in an engineering way with no fewer than 1,700,000 stations, or about as many stations as there are in the British Isles, France, Belgium and Italy combined.

With a keen love for his profession, and pronounced ability, Mr. Thurber soon secured recognition as a coming man, and after filling many other positions he was made assistant chief engineer in 1893. Only a year later he was appointed general superintendent, holding that continuously for the next twelve busy years of rapid growth of the system. In 1908 he was elected vice-president and general manager; and four years later he became vice-president to the Eastern group of Bell Telephone Companies operating over the vast region of the Middle Atlantic States, the most densely populated section of the country. In October, 1919, Mr. Thurber became president of the company he had once entered in a relatively minor position, resigning at the same time in order to concentrate time and energies from the vice-presidency of the Bell Telephone Company of Pennsylvania and associated companies; also from the Chesapeake and Potomac Company and associated companies.

Those who are at all familiar with the telephone industry will realize what an immense amount of work and thoughtful activity this brief outline includes. Mr. Thurber's entire professional life has been devoted to the extension of the telephone business in its great period of flowering and fulfillment. He is an integral part

of the record thus made by that wonderful invention and public utility. To think largely and plan bravely has been an essential factor in his career, as he traveled onward in a group of great co-workers in the telephone public utility.

Mr. Thurber has always been a student both within and outside of his profession. Needless to say, the telephone has problems not only of its own, but most of the social and engineering problems come to bear on the telephone in one way or another. Knowledge of men has also been a factor in his success, particularly in the selection of a capable and competent staff. And back of all this, it is obvious, has been a marked skill in administration, for no great modern public utility can be managed and directed without that.

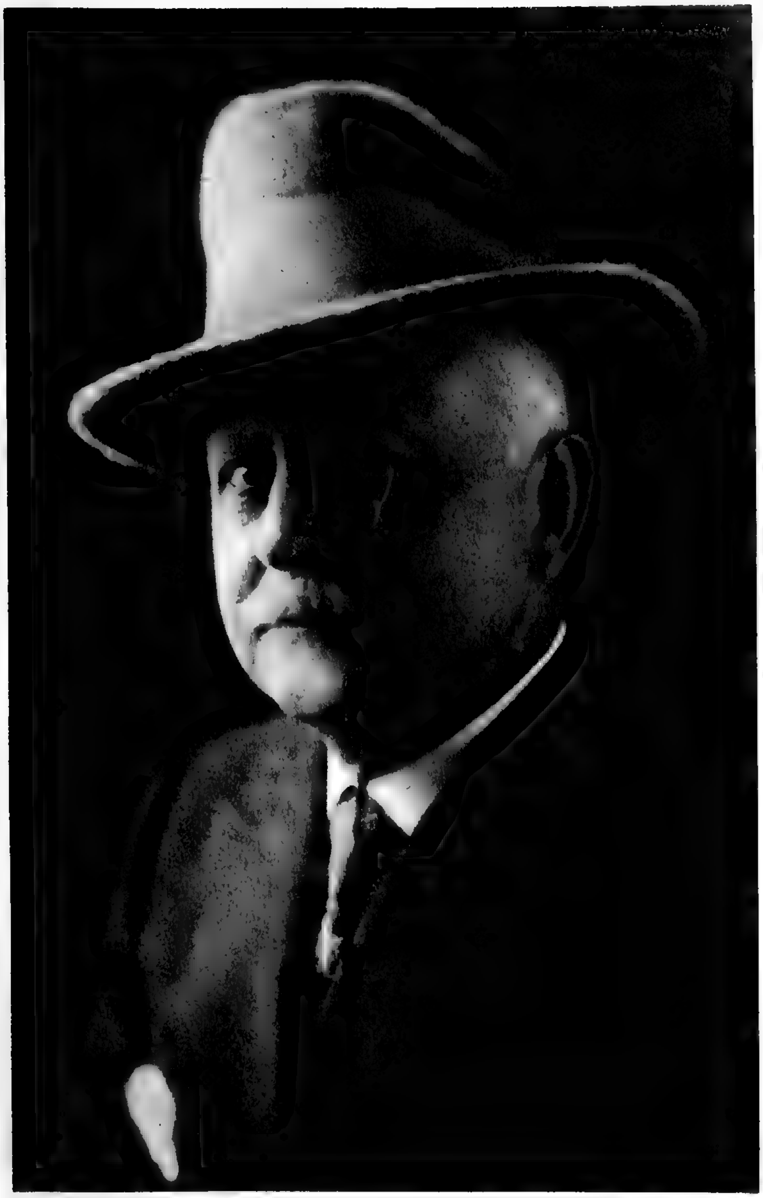
A lover of outdoor sports and a disciple of the gentle Izaak Walton, it is not remarkable to find Mr. Thurber a member of the St. Maurice Fish and Game clubs—and, being unmarried, club life means a good deal to him as a citizen of the metropolis. He also holds membership in the University and Railroad clubs. He is a member of the American Institute of Electrical Engineers, and his offices are at 15 Dey Street, New York.

ALFRED O. TATE

An unusually varied and interesting career is that of Mr. Alfred O. Tate, to whom is due one of the very latest of the new electrical arts, that of waterproofing textile fabrics, of which some details are given separately in connection with this more personal sketch. He was born April 22, 1863, at Peterboro, Ont., Canada, receiving his education at the Collegiate Institute there. But his grandfather, Robert Tate, came from Alnwick, Northumberland, England, settling in St. Lawrence County, New York, in 1817, when Alfred's father, John W. Tate, born at Alnwick, was only five years old. Robert Tate was the first civil engineer to enter that part of New York State, surveying and laying out the County itself. Subsequently, in association with his two sons, Alfred O.'s father and a younger brother, Thomas B. Tate, both civil engineers, he constructed the first railways to pass through St. Lawrence County. About 1850 John W. Tate went to Canada, in practice of his profession, and was one of the engineers who built the Grand Trunk Railroad.

With such antecedents young Alfred took to railroad telegraphy like a duck to water, and May 1, 1878, at the age of 15, he became telegraph operator and train despatcher, having learned the art in six weeks on a promise of the job with the Victoria Railway, Lindsay, Ont. He is proud of the fact that he never had a wreck—some achievement for a novice dispatcher running heavy lumber trains on single-track lines in the days of the hand brake and red flags and lanterns, instead of semaphores. In 1879 he became assistant dispatcher on the Midland Railway of Canada, and went as secretary to the superintendent of the Hamilton & Northwestern Railroad and the Northern Railway, 1879-81. Back to the Midland, 1881-2, he entered the engineers' department and then went as secretary to the superintendent of motive power of the Norfolk & Western R. R., Shenandoah Valley R. R., and the Roanoke, Va., Machine Works.

May 1st, 1883, Mr. Tate joined Mr. Edison's Construction Department and participated in the installation of the first and pioneer incandescent electric light stations outside of New York City. In 1884 he went to Montreal on a special mission and installed the Edison isolated system in the offices of the Montreal "Gazette" and in the local post office. During this period also he installed a municipal lighting plant in the town of Sorel, P. Q. In the Spring of 1885 he returned to New York under the instructions of Mr. Edison on the development of the phonoplex system of telegraphy, in connection with which he was again sent to Canada, and made the first long distance phonoplex experiments on the lines of the Great Northwestern Telegraph Co., between



ALFRED O. TATE

Toronto and Port Hope. Mr. Edison gave him as receiver of this system the old Edison "chalk" telephone, whose operation involved the principle of electric osmose. It was the knowledge gained concerning this action, while thus engaged, that enabled him later to recognize the possibilities of the electrolytic waterproofing of textile fabrics, and to develop the Tate electrochemical processes and electro-mechanical devices with which he has reduced it to successful practice.

In 1886, when Mr. Samuel Insull went to Schenectady to organize and create the Edison Works there, that have since grown steadily and naturally into the colossal General Electric factory, Mr. Tate succeeded him as private secretary to Mr. Edison, a position which he occupied among others until May 1, 1894, when his association with the Edison interests terminated. The other positions he held in the period thus closed were: secretary of the Edison Lamp Company, the Edison Phonograph Company, the Edison Phonograph Works, the Edison Ore Milling Company, the Edison Electric Light Company of Europe, and vice-president of the North American Phonograph Company.

Mr. Tate is certainly one of the founders and fathers of the motion picture art. The first machine produced by Mr. Edison in that field was known as the Kinetoscope. It embraced a film somewhat larger than the present ones, actuated by a method very similar to that which governs the present projection machine. The film images were visualized through a stereoscope set vertically above them and thus thrown into relief. "In 1892," says Mr. Tate, "I organized a small syndicate and made a purchase contract with Mr. Edison for the delivery of the first 25 kinetoscopes he should turn out. It was hoped that they would be ready for the Columbian Exposition at Chicago held in 1893. They were not completed in time and deliveries were delayed until the Winter of 1894. In the Spring of that year I leased the premises at 1155 Broadway, New York City, where I installed ten of these new and novel machines, opening the exhibit to the public about April 15. This exhibition was maintained for about eighteen months, and was in reality the first public demonstration of the modern motion picture as the art is known and practiced today. The kinetoscope combined every essential feature that exists today with the exception of a projecting device to throw the images on a screen: that was a later development."

In 1889 Mr. Tate accompanied Mr. Edison to the Paris Exposition. The six years between 1894 and 1900 he spent in the American Far West, most of the time in California and Arizona, where he was associated with certain mining interests. In 1900 he resumed electrical work on his own account, being impelled back to it by sheer love of the art; and started to develop an electrolytic waterproofing system, following on into the new epoch-making waterproofing of fabrics.

Mr. Tate is a member of the Franklin Institute, by which he was awarded in 1921 the Howard N. Potts Gold Medal; the American Institute of Electrical Engineers, the American Electro-Chemical Society, the Providence, R. I., Chamber of Commerce, the Canadian Society of New York, and the British Schools and Universities Club of New York, and is a member of the board of governors of the Canadian Club of New York. He is also naturally a prominent member of that unique brotherhood, the Edison Pioneers, an organization of the men directly associated with the great inventor in the perfection and introduction of his telegraph, telephone, electric light, and other inventions prior to 1886.

THE A. O. TATE INVENTIONS

It will have been gathered from the biographical sketch of Mr. Alfred O. Tate that he is to be credited with several inventions and improvements in the arts. One of these is the Tate Electro-Septic Water Purifier, designed for office and house use. It consists of an upper and lower tank, with a capacity of two gallons. In the upper are the purifying electrodes, which can be connected to any outside source of electrical energy. An indicator arm on the dial face of the upper tank, with numerals for minutes, is moved first

by hand, and then its subsequent action is automatic. The forward movement of the pointer closes the circuit and starts electrolytic action in the upper treating chamber. Spring mechanism carries the pointer back to zero, after the predetermined duration of the process is complete; opens a valve in the upper tank; and the contents flow to an intermediate filter tray, holding a special filtering paper which arrests the now sterilized suspended matter, and leaves the pure water free for use as it flows into the lower consumption chamber. The period of purification by current is, of course, governed by the local conditions, and by chemical analysis of the water to be treated. The filter papers are supplied in paraffined, sealed tissue envelopes. A new supply of water must obviously be used with each operation, which insures practically ideal conditions for purity and cleanliness. Other such Tate apparatus of a larger calibre is built for hospitals, hotels, railway depots, banks, lumber camps, etc.

A great deal of effective work has been done by Mr. Tate in the perfection of the storage battery. His best known cell is the Tate Bifunctional Accumulator Plate type, which was brought to the attention of the American Electro-Chemical Society in 1911. The plate receives its name from the fact that it contains within itself the positive and negative elements—so that each plate is virtually the cell. In this plate the current enters at the top and exits at the bottom of a finely subdivided multiple-assembled unit provided with an alternating series of anode and cathode conducting strips, knurled so as to present an almost infinite number of minute points and depressions, resulting in a high degree of oxidation and a minimum of "sulphating." The plate, discharged to zero, has been fully recharged in 45 minutes. The standard weight is about 4.5 lbs. per unit plate, with a capacity of about 75-watt hours. This gives the bald element, stripped for an elemental test, 16.5 watt-hours per pound. In service batteries, the weight, which varies with the conditions of service, is usually about one pound per 11 or 12 watt-hours. It has an energy efficiency of over 70 per cent, is easy to manufacture, and its principle is such as to ensure long life. The cell also embodies a new highly improved form of plate separator.

Electrolytic waterproofing is, however, the invention and new art upon which Mr. Tate puts chief emphasis as thus far his best work. Made now under the well-known trade-mark "Tatelec," the goods thus produced are already in wide acceptance and enjoy a growing popularity. The art of electrolytic waterproofing and "converting" of textile fabrics has been developed by a long series of studies and experiments by Mr. Tate; and its processes involving the design and production of beautiful new electrical and mechanical apparatus, are covered by a large group of fundamental patents, which go back as far as 1909, although the present methods and devices are of later and highly progressive origin. Mr. Tate is now a restless inventor, seeking something new before the old has yielded its best results, but is ever building up his system on lines that, when viewed in the retrospect, are seen to be scientifically evolutionary and inevitably consecutive. When Mr. Tate first took up the subject in 1907, there was no prior art, and but one or two primitive patents were extant in the field —the simple methods, if even crudely worked out, having "got nowhere" electrically; so that the waterproofing of fabrics was limited to chemical and mechanical processes. The latter embrace all the methods by which a coating of some water repellent substance is deposited on the surfaces, yarns or fibres by chemical reactions. The former, mechanical, may be said to deal with direct impregnation, filling or coating the fabric with waxes, rubber and compounds. But in view of the fact that the vast majority of garment users require ventilation in the fabric, the loading in this fashion tends unavoidably to render them unsatisfactory for apparel, both as to comfort and particularly as to hygiene. The problem as it presented itself to Mr. Tate was the discovery of a process that would permanently, and not temporarily, suspend capillary action in silk, wool, cotton, etc., and their admixtures, without decreasing the porosity on which ventilation depends.

Through his method so brilliantly worked out, Mr. Tate by electric endosmose fills the microscopic pores of these fibres with a combination of insoluble metal salts, and effects an integral chemical combination of the salts with the fibre by the use of a series of electrolytic rolls or plates, the reagents being applied to the fabrics both before and during such treatment. The result is indescribably perfect. The substances cannot be displaced from the fibre by any kind of mechanical friction or dislocation because they have become part of it; and, equally, the proofing is not affected by any such solvents as gasolene, benzine, alcohol, etc. Hence, dry-cleaning is possible without any sort of impairment of the water repellent qualities. Alumina salts are the preferred ones in use. They are well known in regard to their ability to fix fugitive dyes. The fabrics also become most startlingly mildew proof. A most notable further gain from the Tate process is that in "converting" the goods—more especially cotton—the effects are manifest in a curious but most appreciable thickening of the material. Although there is no appreciable increase in weight, the processed goods feel heavier than those which are "untateized." In its physical aspects the Tate process is extremely delicate in its relation to the fibre organism; and the quantities of metal salts deposited in a square yard of any textile fabric is so infinitesimally small as to be almost negligible. It has also been found that by tateizing the goods, and by calendering under certain conditions of heat and pressure, lustres and sheens are imparted to cotton goods hitherto associated only with natural silken fabrics. But the theme is inexhaustible in its fascination and in the commercial advances and possibilities unfolded.

To carry through this group of Tate inventions, for which the Franklin Institute of Philadelphia awarded to Mr. Tate in 1921 the Howard N. Potts Gold Medal, The Tate Electrolytic Textile Processes, Inc., has been formed with the inventor as president, and with financial support than which there is none stronger in America. Besides an initial plant in New York City, a fine plant has been installed in the famous old Cranston Print Works at Providence, R. I., bought for the purpose, and those factories are being rapidly electrified throughout. Having a present bleaching and printing capacity of about 30,000,000 yards a year, they have now been given an additional electrical waterproofing capacity of about 30,000,000 yards a year, in cotton, wool and silk fabrics. All this, however, is but a beginning, for it can be seen that Mr. Tate has opened a new chapter in American electrochemical industry.

ROBERT I. TODD

Robert I. Todd was born at Lakewood, New Jersey, November 29, 1869. After completing his school education, he entered Johns Hopkins University and received the degree of Electrical Engineer in 1893. Mr. Todd acquired early the

ROBERT I. TODD

habit of constant application to work which has been noted throughout his career, and while in college his summer vacations were spent in working through the shops of the Baxter Motor Company, Baltimore, Maryland, and in the employ of the Traction Company at Raleigh, North Carolina, one of the first electric lines in the country, where he acquired practical experience in the shops and other departments. After graduating he became connected, as Superintendent and Electrical Engineer, with the Eckington and Soldiers' Home Railway Company, Washington, D. C., which was later consolidated into the City and Suburban Railway, and still later, into the Washington Railway and Electric Company. In 1899 he left this Company and became Chief Engineer of the American Air Power Company, New York, N. Y., which company had undertaken the development of compressed air motors for the Metropolitan Street Railway, New York City.

Mr. Todd later became more directly connected with the Metropolitan Company being associated with Mr. Starrett, who was then Chief Engineer. In 1900 he went to Pittsburgh as Master Mechanic in charge of the shops and power houses of the Consolidated Street Railways which is now included in the system of the Pittsburgh Railways Company.

In the early part of 1901 Mr. Todd was chosen Vice-President and General Manager of the Cincinnati Traction Company, leaving this position in 1902 to assume general supervision of the engineering work of the electric railway properties of the United Gas Improvement Company, Philadelphia, Pennsylvania, particularly in connection with the Connecticut and Rhode Island properties which were purchased by the United Gas Improvement Company, and later taken over by the New York, New Haven and Hartford Railroad Company.

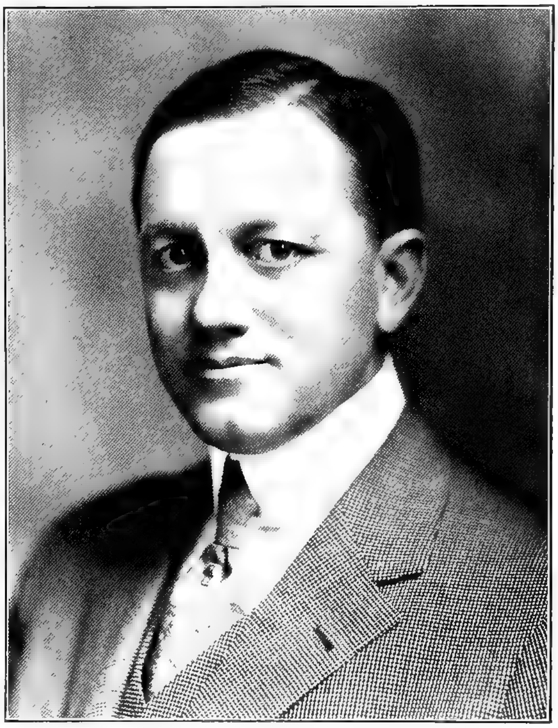
In March, 1903, Mr. Todd was appointed general manager of the Rhode Island Company, which controlled the city lines in Providence, Pawtucket, and adjoining city, as well as the suburban lines of the Rhode Island Suburban Railway Company, and Interstate Railway Company, running to Attleboro, North Attleboro, Plainfield, etc., Massachusetts. During his connection with the Rhode Island Suburban Railway Company, Mr. Todd supervised construction and completion at that time of the Manchester Street power station. On January 1, 1906, he went to Indianapolis to become Vice-President and General Manager of the Indianapolis Traction and Terminal Company (now the Indianapolis Street Railway) and when the Terre Haute, Indianapolis and Eastern Traction Company was organized in 1907, and consolidated various interurban properties, Mr. Todd also became Vice-President and General Manager of that

company. Upon the death of Hugh J. McGowan in 1911, Mr. Todd succeeded him as President of the two properties. The new West Tenth Street Generating Station of the T. H. I. & E. Traction Company, one of the most modern in the central West, was constructed and equipped under his personal direction. Mr. Todd was President of the American Electric Railway Transportation and Traffic Association in 1912, President of the Central Electric Railway Association in 1920, and is now President of the American Electric Railway Association. He is a member of the American Society of Mechanical Engineers, and an associate member of the American Institute of Electrical Engineers.

FRANCIS ARTHUR VAUGHN

Francis A. Vaughn, electrical engineer, was born at Prairie du Chien, Wisconsin, December 6, 1871, and was graduated as Bachelor of Science in his profession from the University of Wisconsin in 1895. He was with the Milwaukee Electric Railway and Light Company for fourteen years, his work embracing practically every phase of low-tension and high-tension, direct-current and alternating-current construction, generation and transmission.

In the way of pioneering, he has been privileged to do his share. In this connection, he has operated the first four upright, marine-engine-type, continuous-current, Edison 3-wire units; superintended the meter-department when Edison chemical meters were in vogue, and changed the entire system to original Thomson, continuous-current, motor-type meters; installed the early 13,200-volt to 600-volt, 25-cycle, railway rotary converters; designed, installed and operated one of the early 3,300-volt, 25-cycle, alternating-current, interurban railway systems; planned and constructed aluminum and copper, long-distance, high-voltage, steel-tower transmission lines in the days when the problems of proper stresses, spans and insulation were still unsolved; passed through the pioneer "grief," connected with the breakdown of rubber and paper cables when used on high-tension, single-phase and 3-phase, station- and sub-station-work before the effect of, and remedy for, static discharges and harmonics were known and understood; designed and built stations and sub stations when stone and bus-bar switch-compartments, fittings and equipment had to be designed, as well as manufactured on the job; was secretary in charge of publication of the first 1,100-page "Electrical Meterman's Handbook," compiled by the National Electric



FRANCIS ARTHUR VAUGHN

Light Association Committee on Meters; was the first to bury street-lighting transformers underground; and successfully designed high, light-weight, ornamental concrete, street-light posts, and other details of the Milwaukee street-lighting system, which is constituted largely of pioneer work.

His reputation firmly established, Mr.

Vaughn headed the firm of Vaughn & Meyer, consulting engineers, opening offices at Milwaukee and Wausau, Wisconsin, in 1910. In 1913 the firm became Vaughn, Meyer & Sweet, continuing until 1916, when it reverted to the original name—Vaughn & Meyer. In 1916 Messrs. Vaughn and Meyer joined Mr. Pillsbury, of Charles L. Pillsbury Company, but still operated as Vaughn & Meyer in Milwaukee and as Charles L. Pillsbury Company in Minneapolis and St. Paul. Later, Mr. Pillsbury left the organization to enter the industrial field, and in April, 1920, Mr. Vaughn assumed entire control of the Vaughn & Meyer organization, operating in Milwaukee only, and Mr. Meyer assumed the Charles L. Pillsbury Company, operating in St. Paul and Minneapolis.

A human dynamo when it comes to work, Francis A. Vaughn has learned to swing half a dozen big jobs at a time with an ease that amazes his associates. Some of these jobs require many months of activity, as, for instance, those done for large manufacturing concerns. Here Vaughn and his men go into a plant and beginning their industrial engineering survey stick until they have reduced every last detail of the problem in hand to an exact science. When they leave the manufacturer knows just where he stands; the needs of the present have been determined and the demands of the future have been anticipated, both with a skill that dispels any and all misgiving.

But pressed though he is for time Mr. Vaughn manages to serve the city and county of Milwaukee as Consulting Illuminating Engineer on new street and highway lighting systems. The remuneration is not large, but it is Mr. Vaughn's doctrine that no man is too busy to do something for his own community. One engineering project alone for the city of Milwaukee took up five years of his time and cost him personally thousands of dollars. It is known the country over as the Milwaukee system of street-lighting. This was an undertaking which at first glance led some folks to shake their heads and declare, "It can't be done." But Vaughn showed them it could; foresight—the foresight that sees flourishing communities where there are only prairies, that visualized the wants of the to-morrow—this was the faculty that spurred him on.

The same foresight prompted Mr. Vaughn to accept when Oscar Werwath asked him to become Vice-President and Business Manager of the School of Engineering of Milwaukee; he looked ahead and saw the possibilities of such a school in point of usefulness. This school trains boys and men in every branch of electricity and electrical engineering. Vaughn understands boys. He knows that many a laggard in rules of syntax can learn by doing things with his hands. Now, almost all boys are particularly interested in electrical connections and circuits—let them handle these in school, and watch them learn. This was the principle he went on when taking hold of the Milwaukee school. It has worked. To-day more than half of the 2,000 students are employed in Milwaukee industrial and commercial plants. Under the school's "Earn-while-you-learn" plan a boy attends school half-time and works the other half in some local plant.

Always looking forward to to-morrow—that's Vaughn. Take aviation. He saw its commercial possibilities and formed, from the City Club's Committee on Transportation, the Aero Club of Wisconsin, well-known in connection with the Lawson Air Cruiser and many other notable aerial events.

Always busy—head of his firm, vice-president of the School of Engineering of Milwaukee, president of the Midland Public Service Co., president of the Francis A. Vaughn Mfg. Co., secretary and treasurer of the Jocelyn Shoe Co., member of a dozen active committees; member of the National Electric Light Association, American Institute of Electrical Engineers, Illuminating Engineering Society, American Society of Mechanical Engineers, Milwaukee Electric League (twice President), Wisconsin Engineering Society, Engineers' Society of Milwaukee, Society for the Promotion of Engineering Education, and member of Rotary as representative of the consulting engineering profession.

JOHN T. WALBRIDGE

Graduating from the Armour Institute of Technology, it was natural that Mr. John T. Walbridge should "throw his hat" into the maelstrom of Chicago when he began active work as an engineer; for that wondrous city is no less the creation of engineering than of trade in wheat and hogs. Born September 13, 1885, at Dallas, Tex., he graduated in 1907, Phi Kappa Sigma being his college fraternity, and he was also a member of the Eta Kappa Nu Fraternity. He took special courses in both civil and electrical engineering, and took the degrees of B.S., E.E., and C.E. Always keen to engage in constructive activities he became at once employed in engineering work for which he was now well prepared. But Chicago is a tremendous stimulus to ambitious youth, especially when it sees the limitless opportunities and has both the desire and ability to lead in new enterprises. Hence it did not take Mr. Walbridge very long to become his own employer; and at the end of only four years he organized and conducted an engineering company to carry out ideas he had already crystallized on his way forward. His experience was large and varied, his connections being with John Metcalf & Company, Bates & Rogers Construction Company, Morava Steel Construction Company, and George W. Jackson, Inc. While with the latter company he was general superintendent and had charge of the construction of the Washington Avenue Tunnel under the Chicago River. He was also superintendent of the construction of a portion of the Illinois tunnel and the rehabilitation of the Chicago elevated loop construction. His own organization is the John T. Walbridge Engineering Company, and he is president also of the Jobst-Walbridge Company. Since going into business for himself he has either designed or constructed (in some cases both) the following improvements: Highway Bridge over Illinois River, Peoria; Peoria water front improvement including designing and construction of dock and diversion of various sewers and public utilities; the Banner Drainage District, electric pumping station; the design and construction of the Spring Lake Marine Ry., a rather unique improvement by means of which river boats are lifted over an embankment and

JOHN T. WALBRIDGE

floated in an interior lake. Construction of Mt. Elliott Avenue sewer including river, dock and tunnel work, for the City of Detroit. The construction of several bridges for the Chicago North Shore Electric Ry.; the construction of dam, filter plant, electric plant and pumping station for the City of Jacksonville; flood protection work along the Ohio River, at Cairo, Ill.; construction of power house for Central Illinois Light & Power Co., and miscellaneous power houses, bridges and other construction work. In addition he handles a great number of engineering problems pertaining to drainage and difficult foundation problems in a consulting capacity.

Mr. Walbridge is a member of the

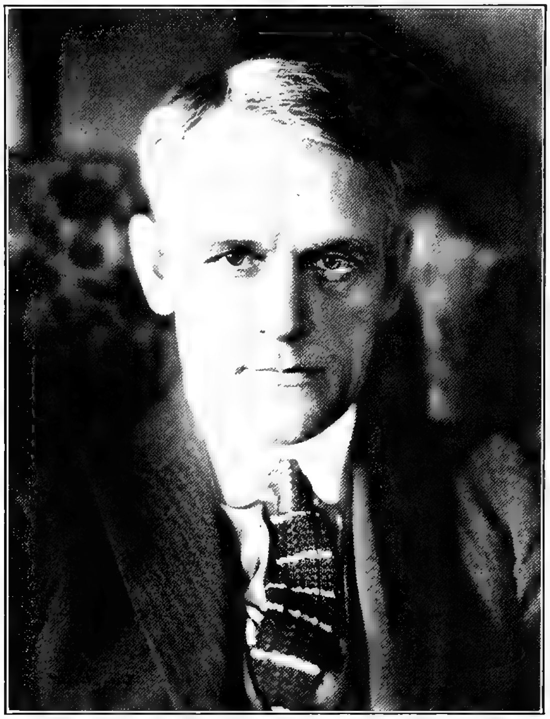
American Institute of Electrical Engineers, the Western Society of Engineers, the Engineers' Club of Chicago and the Missouri Athletic Association.

When not busy—which is seldom—he is ready to play golf or "cut bait and go fishing."

Mr. Walbridge's company has its offices at No. 6 North Michigan Avenue, Chicago.

ROY A. WEAGANT

The immediate success shown by some men in an entirely new field of work or invention often excites the wonder as to what they would have done otherwise, had not the novel opportunity presented itself or been created by them. Roy Alexander Weagant is so supremely master of the art and technique of radio telegraphy, it is difficult to imagine his doing anything except impressing electrical signals and messages on the ambient ether or else improving the methods for doing so.



ROY A. WEAGANT

Mr. Weagant, who is very much at home in the United States, like so many others coming from north of the line of the Great Lakes, was born at Morrisburg, Ontario, Canada, March 29, 1881, studied academic arts at Stanstead High School and College, and in 1905 graduated B.S., electrical engineering course from McGill University, whose training of young electrical engineers ever since Dr. R. B. Owens went there, has been notably brilliant.

Mr. Weagant was a charter member of the Knights of the Round Table college fraternity.

In 1906 he became assistant operating superintendent for the Montreal Light, Heat & Power Company and in 1907 joined the drafting staff of the Westinghouse Electric & Manufacturing Company at Pittsburgh, which he supplemented in 1908 with a special shop course with the DeLaval Steam Turbine Company at Trenton, N. J. Then came the great turning point in his career, for he struck hands with Reginald Fessenden and from 1908–1912 was with the National Electric Signalling Company at Brant Rock, Mass., as designing engineer. From 1912 up to the present date he has been prominently connected with the Marconi Wireless Telegraph Company of New York as chief engineer, making many notable inventions in relation to wireless, and the solution of its "static" problems—a worthy disciple of Sir Ernest Rutherford under whom he had studied physics, witnessing some of his famous Hertzian wave experiments. In 1920 Mr. Weagant was winner of the Leibman Memorial prize for progressive wireless work.

Incidentally it deserves note that Mr. Weagant's first Canadian paternal ances-

tor graduated from Goettingen University as an M.A., going to the Colony in his youth and becoming an Episcopal clergyman there. He was a fellow student of the then Prince of Wales, afterwards King William IV of England, who was also associated closely with Canadian affairs. Mr. Weagant's mother, while the third generation Canadian born, married a native "Yankee" so that, curiously, when Mr. Weagant reached the "Derby Line" in Vermont, on the border, he became, under the laws of the U. S. A., an American citizen, because of this marriage.

Mr. Weagant is a Fellow of the Institute of Radio Engineers and a former member of its board of directors. He is also a member of the New York Electrical Society, the Douglaston Club, Long Island, and the Great Neck Golf and Country Club, L. I., being a keen devotee of all outdoor sports. He resides at Forest Road, Douglas Manor, L. I., his offices being at 233 Broadway, New York City.

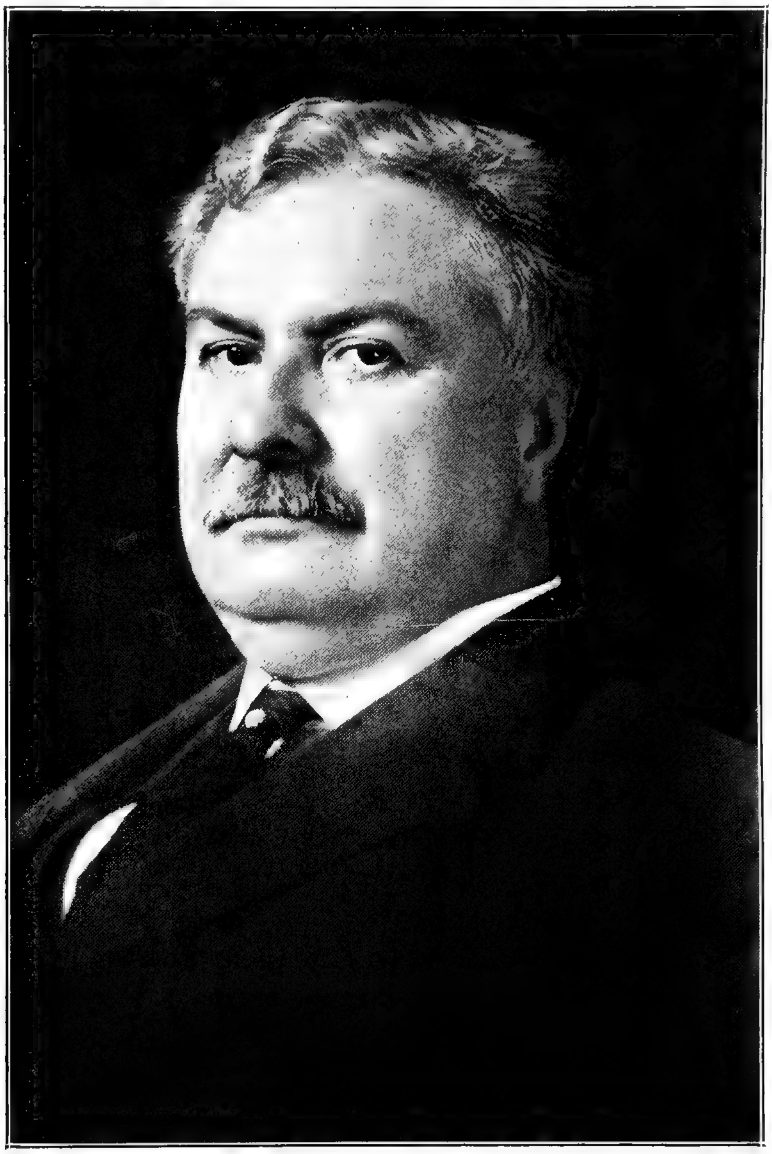
JAMES J. WOOD

The biographical history of the application of electricity to the practical use of man during the past fifty years could not be written without a full measure of credit being given to James J. Wood, inventor of the "Wood" system and father of the closed coil, constant current, high tension, self-regulating series arc dynamo. It has been said that the most important attributes to success are independent initiative ability, honesty and personality. All of these qualities he possesses to the highest degree.

Born March 25, 1856, at Kinsale, Ireland, he came to New York with his parents in the fall of 1864, residing at 55 Broadway where he attended Trinity School and sang in Trinity choir. The family moved to Branford, Conn., in 1867, young Wood entering the employ of the Branford Lock Company. The intricate mechanism used in the construction of all types of locks proved very attractive to Mr. Wood. The character of the work stimulated his inherent mechanical ability, and during the seven years in their employ, he was advanced until he had complete charge of the manufacture of cylinder locks. During this period, not being content with the routine duties, he turned his attention toward steam engines, and although but sixteen years of age, designed a horizontal steam engine, which contained many advanced ideas. This engine was exhibited under operating conditions at a convention held at Branford, Conn., in 1872. For this achievement, Mr. Wood was awarded honorable mention.

About the year 1874, the results of earlier scientific investigators in the electrical field began to be reduced to a practical form. Mr. Wood became very much interested, and wishing to broaden his activities took employment with the Brady Manufacturing Co., of Brooklyn, N. Y., at which time he attended the Brooklyn Evening High School, graduating in 1876, and the Brooklyn Polytechnic Institute, graduating in 1878. In the course of one year's time, he was advanced to the position of superintendent and chief engineer of the company. During the first three years of his employment he devoted his attention to the design and construction of automatic grinding machinery, drill making machinery, shoe pegging machinery, fish hook machinery, etc. This company also manufactured the Brayton oil engine, the drawings for which were made by Mr. Wood, the first double acting engine being installed under Mr. Wood's supervision in the first Holland submarine. Another important achievement directed by him during this period was the design and construction of testing and coupling machinery used in constructing the main cables of the original Brooklyn Bridge. During the latter years of Mr. Wood's

association with the Brady Mfg. Co., it was his good fortune to construct and carry out some of the experimental work for Sir Hiram Maxim. These experiments, which were later coupled with the construction of experimental arc lamps, etc., for Mr. J. B. Fuller, an early investigator in the electrical field, led Mr. Wood to dedicate his efforts to the electrical industry.



JAMES J. WOOD

In May, 1879, the first Wood arc machine was completed. From the first this machine proved eminently successful. The machine was a multi-polar, three phase, open coil dynamo, capable of running one small light of nominal 500 c.p. in each of the three circuits, or when the circuits were combined, one large light of nominal 2,000 c.p. It received the medal of superiority from the American Institute in 1880, and is now in possession of the American Institute of Electrical Engineers. The introduction of this machine, on account of its high efficiency and small weight, caused the company to abandon the manufacture of

Fuller machines entirely, the name of the company being changed to the Fuller-Wood Company. Mr. Wood, however, was not satisfied and continued to make improvements until he brought out his first closed coil machine in June, 1880. This was the forerunner of a type that proved so successful as to be manufactured in large numbers continuously for thirty-five years. The largest arc lighting station in the world, The Narragansett Electric Light & Power Company, Providence, R. I., was equipped and operated for many years with eighteen of these dynamos, with maximum capacity of one hundred lights each. This complete line of apparatus became well known in all parts of the country and was manufactured subsequently by the American Company, the Thomson-Houston Company, the Fort Wayne Company and the General Electric Company, under the name of the "Wood Systems" until a recent date.

During the many years of service with the General Electric Company, as works manager, Mr. Wood has taken out approximately 240 patents, covering electrical and mechanical devices, and embracing arc lighting systems, incandescent alternating current systems, generators, motors, meters, etc. Many of his patents cover work quite foreign to the purely electrical field. One noticeable feature in all of the machinery designed by Mr. Wood is its simplicity of design, pleasing appearance and ease of manufacture. Some idea of his foresight in this direction may be judged from the fact that a line of transformers designed by him in 1896 is still being manufactured at the Fort Wayne Works, the dies for which are reproduced from time to time from the original templates.

It is of more than passing interest to know that the present type of commutator so generally used, is the result of Mr. Wood's inventive genius. This fact is disclosed under patent No. 245040 issued to him in the year 1881.

The popularity of flood lighting so generally used the last few years can no doubt be traced back to the original installation made in America by Mr. Wood in 1885. He proposed this form of lighting for the Statue of Liberty in New York Harbor. His proposition was accepted by the Government, and the successful installation was made and operated for many years, consisting of seven 6,000 c.p. series arc lamps in the torch and eight 6,000 c.p. lamps placed in projectors in the angles of the fort. A curious coincidence is that the fort itself was originally known as Fort Wood.

Mr. Wood is specially gifted, in that he is able to work with his hands as well as his mind. His hand in the execution of his conceptions keeps pace with his mind in designing them. If an artisan was unable to work his ideas into metal for experiments, Mr. Wood has this ability himself and many of his original models leading up to the finished product were the work of his own hand. Whenever he undertook a new design, he never lacked resources to insure success. His care and discretion at interpreting results made his recommendations safe for his company to accept as a practical manufacturing proposition. Those who have been associated with Mr. Wood characterize him as one always ready to help others who are devoted to their work, and striving for success in their chosen field. His manner is one that is always encouraging, illuminating and instructive, and his achievements in life are well worth emulating by those who hope for a successful engineering career.

He is a Fellow of the American Institute of Electrical Engineers and a charter member of the Quarter Century Club. He has received for his inventions many gold, silver and bronze medals, as well as honorable mention from many societies for the work which he has accomplished. At present he holds the position of inventor and consulting engineer for the General Electric Company, and is actively engaged in constructing many new devices tending to increase the use of electricity, particularly in its application to power and household utilities.

GEORGE WESTINGHOUSE

George Westinghouse at the age of 24 had not only invented, but had secured the adoption of the air brake, probably the most important safety device ever known, was justly called "the greatest living engineer." Throughout his career he afforded one of the most remarkable examples of ingenuity, persistence, courage,

GEORGE WESTINGHOUSE

and the chief agency to transform railways from their primitive conditions to their present state of efficiency and magnitude.

George Westinghouse did many other things of first importance to mankind, and became one of the most famous and honored of his time. In his later years he integrity and usefulness that modern history records. From the time when he began to earn his living he was his own master; he never worked for salary or wages; but he did not begin with money; he neither inherited any, nor was given any in any form. At the outset he was his own capital. From his mind came inven-

tions on which he founded industries which, under his direction, grew to huge dimensions. He lived to be the head of great manufacturing establishments which he founded at Wilmerding, East Pittsburgh, Swissvale, and Trafford City, Pennsylvania; Hamilton, Canada; Manchester and London, England; Havre, France; Hanover, Germany; Petrograd, Russia; Vienna, Austria; and Vado, Italy. These gave employment to some 50,000 persons and $200,000,000 of capital.

He was born in the village of Central Bridge, Schoharie County, New York, October 6, 1846. He died in the city of New York, March 12, 1914. He was of American parentage descended on his father's side from German ancestry, and on his mother's from the Dutch. When he was ten years old his parents moved to Schenectady where his father became a manufacturer of agricultural machinery. The father's factory still stands there, and is still conducted under the Westinghouse name.

A clearer understanding of the man is gained if we know something of the boy. He was a worker, not only a diligent but a progressive one. During his school years he spent his out-of-school hours, his holidays, his school vacations, in his father's machine shop. He did this because he loved mechanical work. He learned the use of tools, he studied engineering; he had a zealous fondness for mathematics. In his early teens he designed and built a rotary engine.

His energy was phenomenal. He strode from one achievement to another. Nothing daunted him. His life was a succession of contests, but it was also rich in victories. He did not work in the field of pure science, conducting research for the sake of scientific achievement only, but, like his friend Lord Kelvin—one of the greatest scientific minds of the nineteenth century—he was keen for making the revelations of science serve the needs of man.

When he began work on a subject he looked all around it, and through it, and as it were, calculated its expansive powers. From the beginning he practiced the standardization of parts, a course of first importance both to manufacturers and users of apparatus. And when alternating current apparatus was invented he saw, sooner than any one else, the possibilities of that current's service. More than to any other man, the introduction and development of alternating current systems for light and power were due to him. But he had to subdue scepticism, and bitter and powerful opposition in that work. For years he fought every inch of the way, against continuous efforts not only to prevent him but to crush him.

He was the first to take up actively the steam turbine problems to which Parsons, in England, had opened the way by performance of a fast little boat, the *Turbinia.* He bought the Parsons patents for America and applied them to electrical work, driving generators. But as in almost all the cases of his purchase of other men's patents, he had to redesign and rebuild the apparatus "from the ground up" to meet American conditions, and the problems he had set himself. He went through an experience like this with the alternating current patents of Gaulard and Gibbs, with the gas engine and with the air spring. If it be asked why he bought patents only to do the work all over again, the answer is that although he found his way the better way, he always encouraged men who had useful ideas. Himself an inventor he sympathized with inventors, and he knew what it meant to realize the value of new ideas and crystallize them in products.

He backed Tesla financially and with shop facilities in developing the induction motor, which made possible the utilization of the alternating current for power purposes. He built the first ten great dynamos for Niagara; the dynamos for the elevated and subway roads in New York and for the Metropolitan Railway of London. He devised a complete system for controlling natural gas and conveying it through pipe lines for long distances and thereby established the practicability of using natural gas for fuel in homes, mills and factories.

This volume cannot dwell upon all that George Westinghouse did—it can only glance at the nature of his life work. His achievements were great, but greater than all was his character. From association with him men caught inspiration. He ra-

diated enthusiasm and energy. He demanded honest work and honest dealing. All that he was he gave forth to whatever work he had in hand. He imposed no limitations upon his own hours, nor upon his own output of energy. He believed sincerely that his mission was to be useful and he was useful to the extent that few men ever were. His personality was both compelling and persuasive. You believed in the clear-eyed, enthusiastic man whose face was lighted with eagerness and sincerity. And they that were associated with him gave him their loyal affection. He was tireless and knew no fear. He was considerate of other men, especially of labor, and his men knew that. They knew that he was the most constant worker in all the Westinghouse forces, that he could do what any of them could do. Their faith was never shaken. His tastes were simple, his honor never tarnished, his life was open for all to read. He was as unostentatious at the height of his power and fortune, as when in youth. He was a great man.

WILLIAM WURDACK

William Wurdack was a pioneer in the electrical development of St. Louis, Mo., in the beginning of the wonderful modern period of electric light and power. He was born, however, in New York city, September 3, 1858, and is the son of Ignatius and May Wurdack. He attended primary school on Manhattan Island until 1871, when the family moved to St. Louis. He was thereafter a pupil in both the grade and high schools of the city on the Mississippi, and also completed a course in engineering under a private tutor.

In 1873, sixteen years of age, he started in the electrical business in St. Louis, with the late Charles Heisler, whose chief work at that time consisted in the installation of electric fire alarms, calling systems with annunciator bells, etc., and a little later electric lighting apparatus. As is so well known, the close of the "seventies" witnessed a tremendous outburst of interest in electric lighting, and a corresponding activity in the new field. In 1879, the firm installed the first electric lights in St. Louis, for Tony Faust, the famous old restaurateur. Mr. Faust had purchased a generator and fixtures in Paris, France, and the Heisler Company had the novel and difficult task of setting up the plant and installing the circuits in the Faust buildings on the corner of Broadway and Glen Street. This plant consisted of an alternating current generator and Gramme exciter, furnishing current to Jablochkoff "candles" as they were called. At this time, an arc lamp was also shown, operated by a generator built in St. Louis by Mr. Heisler. The first arc lamp was hand fed, and was a great novelty. The result of all this early interest in electric lighting was that Mr. Heisler, an enterprising and progressive man, developed his own system, which was widely known at the time and was quite extensively introduced. Mr. Wurdack continued, naturally, with the Heisler Company, assisting in the development of the popular Heisler apparatus and its installation until 1884, when the St. Louis Illuminating Company was organized, of which he became the superintendent. This pioneer organization built and operated the first incandescent lighting central station in St. Louis. It was the foundation for later enterprises and continued in business until 1890, when it was absorbed by and merged in other interests.

In the same year, Mr. Wurdack organized the Interstate Electric Construction Company of which he was president. This concern continued in business until 1897. After that date, he operated the electrical construction and manufacturing business under his own name until 1904. At that time he incorporated his interests under the name of the Wm. Wurdack Electric Manufacturing Company. He is still actively occupied with its affairs as the president of the corporation, which

WILLIAM WURDACK

specializes in switchboards, panel boards, and devices for distribution and control of electrical energy for light and power purposes. He has thus spent nearly fifty years in the electrical industry of whose early days he has many interesting reminiscences; and he can point thus to a continuity of active interest almost without

equal, in a period of electrical advance that may never be surpassed for its importance as marking the creation of new arts and public utilities.

Aside from his deep engrossment in electrical matters, Mr. Wurdack has been interested in the way of relaxation in photography, horticultural and general outdoor life. While the broad questions of the day have always occupied his thoughts, he has never sought or held public office of any kind.

In 1890, Mr. Wurdack was married to Miss Louise Steber. Their children are William Wurdack, Jr., Arthur, Walter, Pauline and Blanche. The three sons are engaged in the electrical business with their father.

EDWIN RUTHVEN WEEKS

Mr. E. R. Weeks would deserve a place in any record of electrical development if only as the first superintendent of the first central station employing the Thomson-Houston electric lighting system and first manager of one of the earliest central stations using the Edison system; while a little later his work typified all the modern practice when he became manager of one of the first Westinghouse lighting stations. He is fitly known as "The father of electric light and power in Kansas City" in recognition of such notable pioneer work.

Although proud of this and of being the third president of the National Electric Light Association (1889-90), he is not less worthily proud of his pioneer presidency of the Humane Society of Kansas City and activity in promoting artistic and political reform movements. As a member of the firm of Weeks & Kendall, he has to his credit several notable pieces of engineering and electrical construction. Born at Westfield, Ohio, December 25th, 1855, Mr. Weeks is a graduate of the famous Phillips Academy of Exeter, N. H.

GEORGE E. WELLS

Ex-President George E. Wells, of the Society of Refrigerating Engineers, also occupies a distinguished place in electrical engineering. Several times have we been called upon in this publication to outline the achievements of men who were natives of the territory in and around Terre Haute, Ind. He is another instance, as here noted.

Mr. Wells was born in Vigo County, Ind., April 29, 1875. After the Terre Haute public schools he entered the Rose Polytechnic Institute and graduated in 1896 with the degree of B.S., taking a special course in engineering; he was later given the degrees of M.S. and E.E. From 1898 to 1901 Mr. Wells was connected with the engineering department of the Wagner Electric Manufacturing Company of St. Louis. Since the latter date he has been engaged on his own account in general practice as a consulting engineer. In recent years he has given much attention to the branch including ice making and refrigerating.

Mr. Wells is a member of the American Institute of Electrical Engineers; the American Society of Mechanical Engineers, as well as the Engineers' Clubs of St. Louis and New York. His home is in St. Louis and his office in the Boatmen's Bank Building of that city.

FAY WOODMANSEE

FAY WOODMANSEE

Born at Fulton, N. Y., October 27, 1874, Mr. Fay Woodmansee is amongst those who went West to grow up with the country and to find his fortune. His youthful education was received at the public schools of Ann Arbor, Mich., from which by easy remove he proceeded to the University of Michigan, which has long enjoyed a high reputation for the quality of its engineering training and ability of its engineering graduates. He completed his courses there in 1898, with the degree of B. S. (E.E.). As early, however, as 1897, he began engineering work, and then after graduation he went in 1898 to take part in work for the U. S. Government on a deep-water survey, from the Troy, N. Y., dam to Germantown, on the Hudson River. This brief preliminary practice as a civil engineer only paved the way for his entry next into the ranks of the General Electric Company, with which great concern he was engaged from January 1, 1899, to January 30, 1903, in the switchboard department, then developing into a great branch of engineering construction. Out of this other opportunities arose, and Mr. Woodmansee at last left to join the staff of Sargent & Lundy of Chicago, universally famous for their central station and power house undertakings. He remained with the notable firm of engineers for nearly ten years during an active period of construction; and did not leave them until May 1st, 1911, and then only to engage in business for himself with Mr. C. J. Davidson, under the firm name of Woodmansee-Davidson Engineering Company, located at 208 La Salle Street, Chicago, Ill.

This marks a distinct stage in Mr. Woodmansee's career and his new departure in engineering and manufacturing work on his own account. In 1910 he had, however, helped to found the Electrical Engineers Equipment Company, of which he is now president, being in full control of its destinies and affairs. These enterprises alone do not constitute the full record by any means, as Mr. Woodmansee is not only a director in the Moloch Stoker Company, but he is also active in the public utility side of electrical business. Thus, he is vice-president alike of the Central Utilities Securities Corporation, the Commonwealth Public Service Company of Delaware; and the Mid-Continent Oil & Utilities Company. Such a record furnishes unusual evidence of wide-spread interest and activities in all branches of the great electrical field. Mr. Woodmansee is both a Fellow of the American Institute of Electrical Engineers, and a member of the American Society of Mechanical Engineers. He is also a member of the busy and progressive organization, the Electrical Club of Chicago and of the University Club of Chicago. He is interested in Masonic matters, and as a member of the Masonic Order belongs to Medinah Temple, Chicago.

HUGO WURDACK

For many years past, prominent in the electrical development of St. Louis and Missouri, Mr. Hugo Wurdack has carried his aggressive enterprise and executive ability into other cities and States, and now operates public utility properties also in Illinois, Ohio, Texas, Kentucky, and South Dakota. He was born March 9, 1871, and after education in the St. Louis public schools and in private night class and courses, went to work for the St. Louis Illuminating Company in 1888 as a lamp inspector. After six months of that he went into the electric plant itself as an operator, spending thus the next two years, until 1890. At that time he enrolled with the Laclede Gas Light Company in charge of the electric plant and continued with it in various capacities, ending as station superintendent in 1903. In December of that year he became associated with the Laclede Power Company of St. Louis as assistant manager, a position he held until December, 1907. At that time he could not resist any longer the growing ambition and resolve to engage directly in the management and operation of public utility properties, and therefore organized the Light & Development Company of St. Louis. It was a modest corporation at the start, but from $5,000 in 1907, Mr. Wurdack built it up to a $3,000,000 group utility in 1916, by which time it had become widely known; while Mr. Wurdack's managerial ability was equally recognized. From the very outset he was not satisfied merely with the ordinary elements of finance and engineering, but took very broad views as to the relations of the public utility to the people served and to society in general. Mr. Wurdack was always deeply interested in fighting the municipal ownership craze and took an active part in bringing the public mind to the saner, sober views that now prevail as contrasted with the "prairie fire" spread of the doctrine about ten years ago.

Aside from this work of a highly constructive character, as president of the Light and Development Company, Mr. Wurdack organized the United States Public Service Company operating in a large area of the Middle-West, and South-Western country, and of which he is president. In addition to this he is president of the Missouri Utilities Service Company, the Texas Utilities Company, the Mitchell Power Company, and about seven other kindred corporations. Nor is this all for he has become quite actively interested in and closely identified with the manufacturing side of the industry. Together with T. O. Moloney he organized the Moloney Electric Company of St. Louis, so well known throughout the country as a leader in the transformer art; and he is now its secretary as well as a director. Through both lines of approach he has enjoyed the acquaintance and confidence of many of the men prominent with himself in the electrical field during the past twenty-five years.

Although Mr. Wurdack's gift of eloquence might easily have carried him into politics or the law, he would perhaps say himself that he has been fortunate in finding an outlet for that expression of his character in the church and in its work. Not only has he been superintendent of a Congregational Sunday School for 25 years, but he conducts a mission in which he has preached on Sunday and week nights for 18 years. His Protestant father and mother came from Germany, were married in New York, and of their American family of five sons and two daughters, Mr. Wurdack is the youngest.

He is an associate member of the American Institute of Electrical Engineers, and a member of the American Society of Mechanical Engineers, St. Louis Engineers' Club, National Geographic Society, Missouri Athletic Association and other bodies.

His offices are in the Railway Exchange Building, St. Louis.

HUGO WURDACK

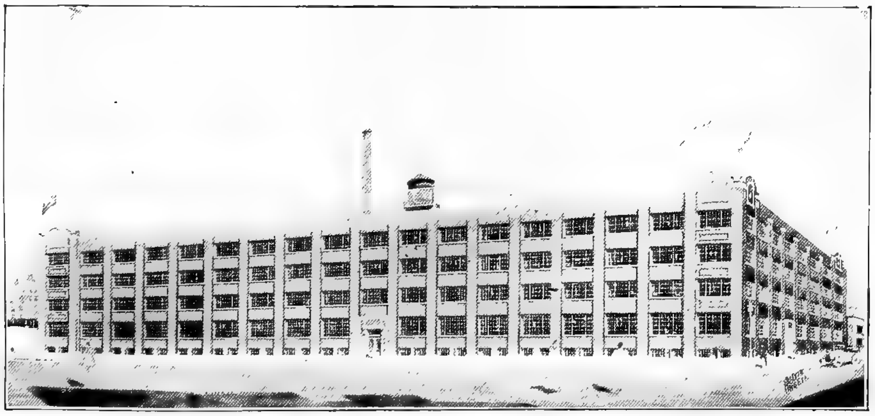
A. I. APPLETON

CHAPTER XXI

COMPANIES AND INDIVIDUALS PROMINENT IN ELECTRICITY

APPLETON ELECTRIC COMPANY

The Appleton Electric Company, Chicago, Ill., manufacturer of conduit fittings, has recently completed the building illustrated here. This new factory was made imperative in order that the company might adequately meet the large demand for its products. It more than doubles the capacity of the early plant, and also results in greatly improved production. The new building is "L" shaped. It is a four-story and basement structure covering an area of over 45,000 square feet. In addition the company is erecting a power house which will occupy 140,000 feet of floor space. The new plant is modern in every respect and is equipped with the most up-to-date machinery. It is located at Paulina and Wellington Streets with a switch-track from the Chicago & Northwestern R. R., affording excellent shipping facilities. The product of the Appleton Company is meeting with increased popularity and the erection of this large plant may be regarded as indicative of the company's optimistic view of the future. Mr. A. I. Appleton is president and treasurer of the organization; Mr. F. H. Merrill, vice-president, and J. B. Painter, secretary. Branch offices are maintained by the Appleton Company both in New York and San Francisco.



Appleton Electric Co., Chicago, Ill.

Mr. Appleton, the president of the company, nearing the fiftieth milestone of his life, has devoted his entire business career

to manufacturing, having been connected with the Chicago Fuse Wire and the Whitely Exerciser Company as superintendent of the manufacturing plant; with the Springfield Drop Forge Company of Springfield, Mass., as superintendent, and with the Acme Flexible Clasp Company of Chicago, also as superintendent. Mr. Appleton purchased a one-third interest in the Harvard Electric Company of Chicago in 1900 and thus became interested in the electrical field and started the Appleton Company of Chicago which he has built up into the magnitude described above.

Mr. Appleton is a member of the Chicago Athletic Association, Evanston Golf Club, the York and Scottish Rite, Oriental Consistory divisions of the Masonic fraternity.

THE BEARDSLEE CHANDELIER MFG. CO.

It is only within the last few years that the importance of scientifically designed and constructed lighting units has been realized. Not many years ago, lighting "fixtures" were regarded solely as things which were necessary to hold incandescent lamps. Since they had to be there, they were made as ornamental as possible, but very often the style of ornamentation was not appropriate for the type of interior or the decorative effect used. Regarded only as a necessary evil and something to look at, the importance of a fixture or chandelier as a factor in efficient illumination was little realized.

Early in the period of development of modern illuminating equipment, the Beardslee Chandelier Mfg. Co., of Chicago, realized the wisdom of balancing the æsthetic with the utilitarian in the designing of a chandelier and also the desirability of keeping the decorative features in harmony with architectural treatment of the interior where the chandelier is installed. With this thought foremost, it built up a corps of designers and draftsmen who have achieved distinction in their work.

In addition to creative ability, not a little of Beardslee success has been due to the craftsmanship of the workmen and the high grade of materials and tools with which they have been provided. The combined effect of these factors has earned for this company an enviable position in the field of quality chandelier manufacturers.

The Beardslee Chandelier Mfg. Co. opened its doors for business in October, 1901. The original incorporators were Frank S. Bearsdlee, president; George M. Beardslee, vice-president and treasurer; Robert Schrumpf, secretary; and Henry Schob, general superintendent. They started business at 253 So. Canal St., Chicago, with 10,000 sq. ft. of floor space. In 1906 they leased an entire building at 225 So. Clinton St., which gave them 15,000 sq. ft. additional space. In May, 1913, this building was purchased to make room for the new Union Depot, now under construction, and they were forced to move to their present quarters, 216 to 220 So. Jefferson St.

In the spring of 1915, they consolidated with the David J. Braun Mfg. Co., but continued under the name of the Beardslee Chandelier Mfg. Co.

Mr. Fred R. Farmer succeeded Mr. Beardslee as President in January, 1918, Mr. Beardslee becoming chairman of the Board of Directors, Mr. Schrumpf and Mr. G. F. Beardslee also retired at the time; Mr. Schrumpf, however, remained as director. In addition to Mr. F. R. Farmer as president, the present officers are C. G. Ricklefs, vice-president, and Benjamin P. George, secretary and treasurer.

About five years ago, the Beardslee

Company put on the market a commercial lighting unit known as the Denzar. This unit makes use of the Mazda "C" lamp, and by means of special enameled glass bowl, opal glass reflector and porcelain enameled deflectors, distributes the rays of the powerful Mazda "C" lamp evenly on floor and walk. The resulting illumination resembles soft sunlight and is noticeably free of glare and harsh shadows. In common with Beardslee catalogued and specially designed chandeliers, the Denzar is sold only through dealers and legitimate jobbers.

The Denzar has so successfully met the lighting requirements of offices, stores, schools, gymnasiums, halls and public buildings, that the Beardslee Company, late in 1919, leased another building at 115 So. Jefferson St., which is devoted exclusively to the production of the Denzar Chandeliers.

THE COOPER HEWITT LAMP

The first practical achievement of electricity was the rapid transmission of thought, as exemplified in the Morse system of telegraphy. The second great achievement was the production of light, as exemplified in the arc and incandescent electric lamps of Brush and Edison. Of these two light-sources the former astonished the world by its power and brilliancy, the latter delighted by its unprecedented convenience and adaptability. But remarkable as these lamps were as scientific discoveries, they did not at first represent an economic advance. Electric light was for many years after its discovery more or less in the category of luxuries. The production of "cold light," that is, light without the enormous waste occasioned by the excess of heat generated in its production has been a sort of "philosopher's stone" to the scientific investigator.

Peter Cooper Hewitt, having the advantage of ample wealth wherewith to indulge his taste for scientific research, turned his attention, while a young man but recently graduated from the Stevens Institute of Technology, to this elusive problem. The only practical means then known of producing light was by heating up a solid body to a temperature at which it becomes incandescent. The so-called electric lamp was, and with one exception still is, simply a device for heating up the body by means of an electric current instead of by combustion, as in the case of flames, which were the only other sources of artificial light. The light produced is simply a by-product of the heat—and a very sparing one, representing only three or four per cent of the energy expended. The only hope of greater efficiency lay in finding a substance having a greater refractory power.

Cooper Hewitt struck out in an entirely new direction on his voyage of discovery. Turning aside from the beaten path of incandescent solids, he sought the answer to his problem in the domain of gases and vapors. The "Crookes tube" a familiar scientific curiosity consisting of a glass tube containing air in a highly rarefied state, which emits a faint glow when a very high tension current is passed through it, was suggestive of possibilities in this field. Cooper Hewitt substituted the vapor of mercury for the rarefied air. This enabled him to use a tube some four feet long, and an electric current of the voltage ordinarily supplied. Furthermore, the light from glowing mercury vapor is of very high visual power, since it consists largely of yellow rays, whereas the light from glowing air is of a cherry red color, which is of low visual power. These were simple facts, easily established. But the practical problem of developing the electrical devices necessary to maintain a constant passage of electricity through a four foot tube of mercury vapor required the discovery of the laws of gaseous conductivity, then unknown to science. Cooper Hewitt worked these out with consummate skill, and reduced them to practice in the form of a commercial electric lamp or tube.

As finally developed, the Cooper Hewitt mercury vapor lamp consists of a glass tube four feet long and one inch in diameter, exhausted of air, and having a small pool of mercury in one end and an iron electrode in the other, each connected with a leading-in wire hermetically sealed into the glass. An electro-magnetic device connected with the tube served to start the passage of the current through the tube by means of a momentary high tension impulse and to maintain a steady flow of current after its passage has been started.

While Cooper Hewitt did not reach the final goal of "cold light," he not only made a distinct advance in that direction, but produced what in some respects is an even more remarkable achievement, a light that, for many important purposes, is actually better than daylight. The peculiar color quality of mercury vapor light materially increases the power of the eye to see small objects clearly; and this property is invaluable in the finer operations of manufacturing. Cooper Hewitt light, therefore, finds its largest use for industrial lighting, where it has frequently shown its superiority to daylight. Its high photographic power has also been utilized in the moving picture industry, where it has taken the place of daylight for studio use, on account of the constancy of its power, and the more artistic effects obtainable by its use.

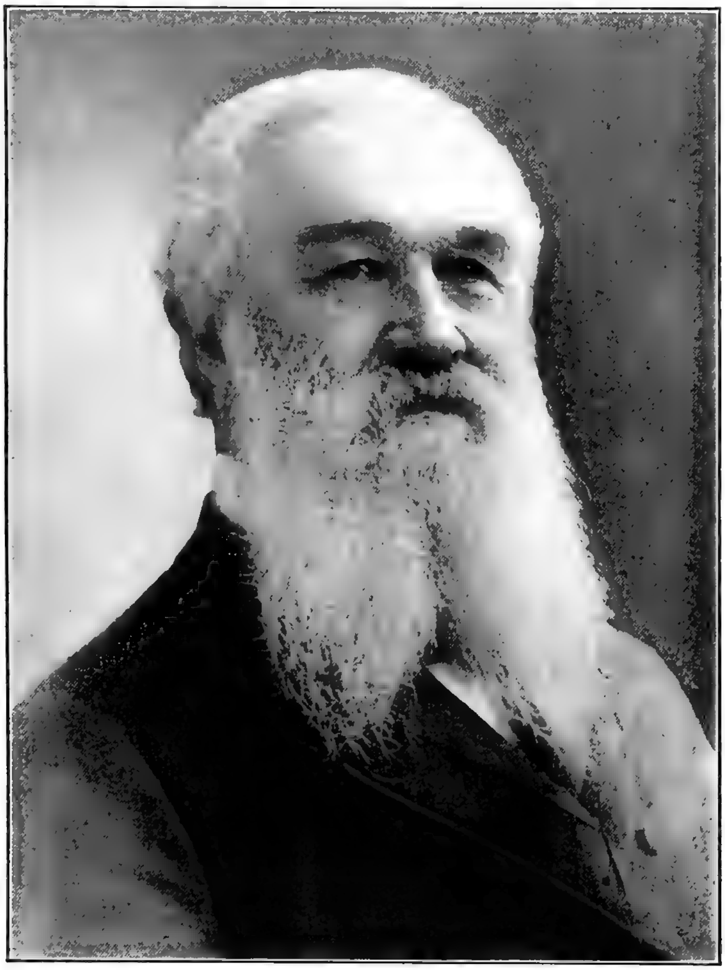
THE HOLMES ELECTRIC PROTECTIVE SYSTEM

By long and distinctive association the name "Holmes" at once suggests "Burglar Alarm," and while the term does not adequately describe the great public service rendered, it does convey a general impression of the business, as is the case in other industries where some pioneer by great leadership has created what is literally a trade-mark in his own name. Seventy years ago, an ingenious electrical device was patented as a "new and useful or improved Magnetic Alarm"; and in 1857, Mr. Edwin Holmes, energetic proprietor of a "notion" store in Boston, impressed with the possibilities of the crude device, bought the patent. The invention consisted broadly in the use of simple springs so applied in the frame of a door or window as to close the circuit when the door, or window, was opened, thus permitting current from a battery to operate an electric bell for alarm purposes. The patent was one of the less than 10,000 which up to that time had been taken out in the United States in all lines.

Needing electrical equipment for the system, which with characteristic energy and confidence he began pushing, Mr. Holmes in 1858 went for it to the historic shop of Hind & Williams, afterwards Charles Williams, 109 Court Street, Boston, where he made the acquaintance of Prof. Moses G. Farmer, one of the great electricians of his time and then very much interested in the creation of the American fire alarm telegraph system. But Mr. Holmes did not find a brisk demand for his novelty in Boston, and shrewdly concluded there would be a better market in New York City, then as now the "crime centre" of the country. Locating his home in Brooklyn, he opened offices on lower Broadway in 1859, and soon had built up a business which from that day to this has worthily carried his name. The best families, the leading stores, the progressive banks, all patronized the Holmes system, to which Yankee ingenuity soon added successive refinements and improvements, some fundamental and persisting to this day. Moreover, in producing needed supplies, Mr. Holmes had a chance to display his own ingenuity, as for instance the weather-proofing silk or cotton wound insulated copper wire, which was made in his Brooklyn back yard. This was continued as a factory industry until 1870 when Eugene Phillips began, in a small way, at Providence, R. I., making insulated wire for such purposes.

In 1871, Harvey Parker brought back from Paris for his famous hotel in Boston, the Parker House, an electric annunciator

that had immensely tickled his fancy; but at that very moment in the Holmes office in Boston they were showing an American device for the same purpose built in the followed by the first elevator annunciator, connected by copper wire drawn into a rubber garden hose, crude enough, but it worked and was the first of its number-



THE LATE EDWIN HOLMES

versatile Williams shops, and which a very few years later not only threw the French annunciator into the discard but invaded every enterprising hotel in the country. A picture of the Holmes hotel annunciator of 1872 looks very modern. It was shortly less tribe. And getting just a little ahead of the story, it may here be noted that Mr. Holmes ran the first wire over the Brooklyn Bridge that ever crossed that structure for telephone purposes.

This period around 1872 was a crucial

stage in the Holmes history and development, for it saw the beginning of the Holmes Central Office system, which in its essence embodied all the wonderful development since seen of the central station and exchange principle in so many different fields of electrical application. A plan was worked out and patented in 1872 for an electrically lined cabinet to envelop a jeweler's safe, and then, instead of merely connecting the cabinet with a gong outside the building or some distant bell, to run all the wires into a central office, manned night and day by a force of trained men, so that in case of any alarm there would instantly be a Holmes "Johnny on the spot."

The idea, though revolutionary, met with immediate acceptance by jewelers, bankers, etc., and the Holmes Burglar Alarm Telegraph Company, with a central office at 194 Broadway, with its galvanometers, switches, and other instruments of novel design, and with aerial circuits radiating from a huge roof structure, became at once a vital, indispensable factor in the business life of New York. But the city was traveling uptown several blocks a year, and a further central was soon opened at 571 Broadway, moving in May, 1878, to 518 Broadway, where one of the larger Holmes offices was continuously located until 1921, remaining open and operative without any interruption for a period of forty-one years! There at "518," as historic as 109 Court Street, Boston, birthplace of the telephone, was started the first telephone exchange in New York City, now by far the largest system in the world.

At this point the sequence of the narrative may be broken, but not interrupted, to tell how closely the evolution of the Bell Telephone is associated with that of the Holmes burglar alarm.

In 1869, Mr. E. T. Holmes, son of Mr. Edwin Holmes, went to Boston to organize on his own account the growing burglar alarm interests there, and in 1872, he opened the Central Office. The electrical apparatus used was still made in the Williams shop, and in May, 1877, the junior Holmes saw Williams using the crude Bell telephone, and with quick intuition realized that here was something not merely new but epoch making.

One day Mr. Holmes offered to Mr. Gardner G. Hubbard, father-in-law and backer of Bell, to connect some telephones into his central office at 342 Washington Street and let some of the bankers on the alarm circuits try the new instruments and talk to each other. This was done, and in the language of the great authority, Mr. Thomas D. Lockwood, there thus began and occurred "the first telephone intercommunication constituting the nucleus or germ of the telephone exchange system." This was obviously also the first telephone switchboard, although the first switchboard built specially for such a purpose was that used at New Haven a little later in 1878. The telephone is "another story" but it was a necessary consequence of this extraordinarily early and intimate relationship that the fortunes of the two Holmeses and of the Holmes burglar alarm system were profoundly affected, and that today when the whole service has been definitely enlarged and reënforced along telephone lines, a close, underlying relation subsists and continues.

Returning in a few years after this exciting interlude of helping to found another great new industry, to the exclusive direction and attention to the growingly popular Holmes service, the father and son in the eighties built up a number of new central burglar alarm offices in leading cities; and after a rather keen competition with the American District Telegraph Company, the latter retired from the burglar alarm field in New York.

The Holmes business was expansively organized in 1883 as an incorporation, with the senior Holmes as first President of the Holmes Electric Protective Company. He was succeeded by his son, who

continued as president until his death in 1920. After the new company was formed in 1883, taking over the business, two new departments never before operated were put into effect, the Watchman's Signal and the Night Patrol System; and the patrol service was reorganized on a police basis, in the neat gray uniforms, with captain and sergeants, and a body of men whose *esprit de corps* has never known diminution.

The present status and extent of the Holmes system may be inferred from the fact that while there are estimated to be of various kinds some 15,000 central office burglary protective lines in the United States, no fewer than 8350 of these, or nearly 60 per cent, are under the Holmes control.

The progress steadily maintained up to the outbreak of the Great War has been resumed and intensified under the strange, exacting conditions of the times, when it is no longer a foe that has to be dealt with at a distance but those more subtle and dangerous enemies whose criminal instincts aim more violently than ever at property and life in the city, the office, and the home. Against such marauders, the Holmes System stands today a more vital protector of society and of life and property than ever.

LOUIS GERARD PACENT

Few men have enjoyed as diversified an experience in the wireless world as Louis Gerard Pacent. Although a comparatively young man, Mr. Pacent has run the entire gamut of radio activities, including student, amateur, technician, inventor, instructor, author, and manufacturer, and his varied experience has resulted in his being recognized by many as the best posted, all-around radio man in the field.

Although Mr. Pacent's career has obviously just begun, its progress thus far serves as a splendid example of the self-made man. When still but a boy, he developed a keen interest in the "ether-art" and his delight was to experiment with the various wireless devices then in use. At school, Mr. Pacent was required by his instructor to submit a drawing from memory. Much to the dismay of the instructor, the work submitted was a design of a variometer, at that time a device little known even to radio connoisseurs.

By persevering study, personal investigation and grasping every opportunity at education relative to his "hobby" young Pacent sought to realize his early ambition of becoming a radio engineer. Today he is president of the Pacent Electric Company, engaged in the production and distribution of his own inventions on a national basis. Strangely enough, the same variometer which the youthful Pacent designed at school is shortly to be added to the comprehensive line of radio and electrical essentials which he now manufactures.

Mr. Pacent's versatility in the radio field is further reflected in his participation in the various engineering organizations. He is an executive member of the Associated Manufacturers of Electrical Supplies and chairman of one of its most active committees; Member of the Institute of Radio Engineers; member of the American Institute of Electrical Engineers, and director and chairman of the Committee on Papers and past vice-president of the Radio Club of America.

During the war Mr. Pacent divided his activities between business and the radio service of the U.S. Army and Navy and succeeded in designing and putting into service several instruments which helped to win the war.

As a student, amateur, and as a consulting engineer and manager of radio

activities of the Manhattan Electrical Supply Company, and through his activity in several of the radio and electrical societies, Mr. Pacent has developed a great multitude of friends. His intimate acquaintances include many of the leading lights in the radio and electrical field, by most of whom he is still familiarly known as "Louie."

Among Mr. Pacent's numerous inventions are: Pacent universal plug, Pacent twin adapter, Pacent multi-jack, Mesco radio buzzer, several sending keys, Duplex inductance mounting, several inductance attachments and several receiving and transmitting sets. His writings include: "Manual of Wireless Telegraphy," "How to Make a Trans-Atlantic Wireless Receiving Set," a number of papers and articles, some of which are as follows: "The Wavemeter in Wireless Telegraphy and Telephony," which was read before the Radio Club of America as early as 1911, the subject being one very little appreciated at that time, but now one of the most important problems in the art since wavelength is the one thing definitely confronted in interference work. "A Radio System for Simultaneous Sending and Receiving," "The Relay Antenna Transfer Switch," "Radio Telephony," published in *Radio News*, etc., etc.

It is told of Mr. George Westinghouse that he could step from his Pittsburgh laboratory into a business conference, having already donned his frock, and at once adjust himself to the subject of engineering, finance, sales, or whatever business problem was under discussion. Mr. Pacent is an ardent admirer and staunch disciple of Mr. Westinghouse, and believes that success depends upon the faculty to efficiently divide one's time and adapt one's self to the task at hand. There is both a practical and visionary side to Mr. Pacent's activities. Many of the conditions which have developed were predicted by him a long time ago. The subject of radio broadcasting, for example, which is on everyone's lips today was one of the things he predicted several years ago. In fact, he started his company with a view to ultimately introducing or helping to introduce radiophone broadcasting and to popularize wireless. As a result, when Mr. M. C. Rypinski first told him of the plans of the Westinghouse Electric and Mfg. Company to introduce radio into the home, he immediately devoted his entire energy to realizing this early ambition.

Although the business in which he is engaged requires a great deal of his personal practical application, he is busy experimenting with a view of solving some of the most pressing wireless problems, particularly supplying equipment for the successful reception of the radiophone in the home.

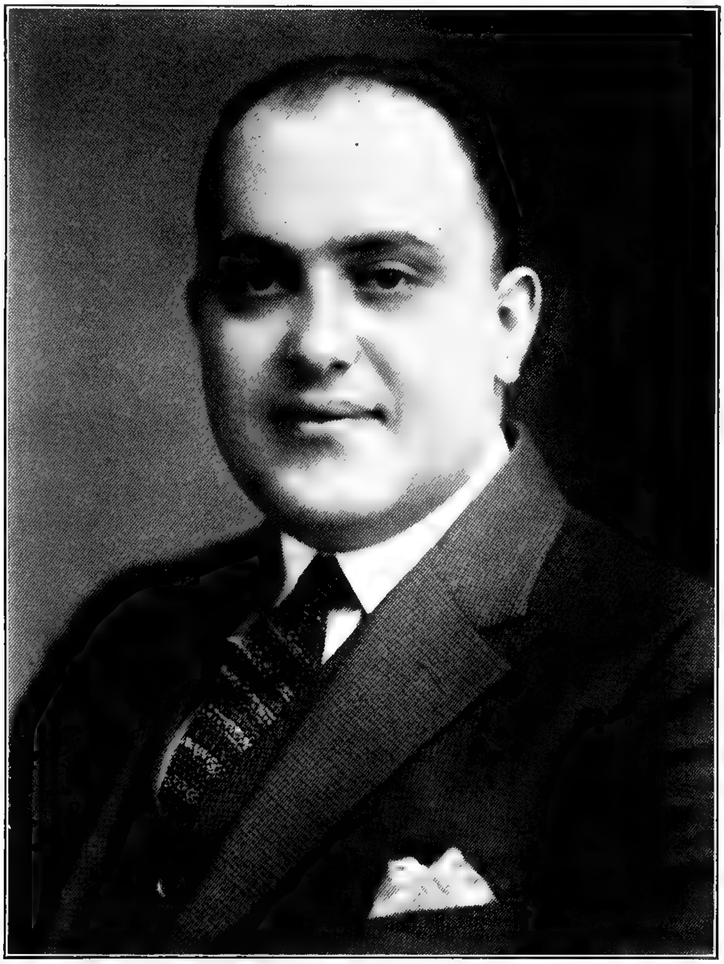
Being a student of wavelengths, Mr. Pacent predicted in 1912 that the Atlantic Ocean would be spanned with one kilowatt at 200 meters, much to the amusement of several prominent radio engineers. In 1919 at a Board of Directors' meeting of the Radio Club of America he suggested erecting an efficient transmitting station of 1 K.W. and attempting to hear it in England on 200 meters. Although the project was looked upon favorably by Major E. H. Armstrong and several other directors present, the plans were abandoned because of the cost of erection. Several months ago the Atlantic was spanned by radio with less than 1 K.W. on 200 meters. Recently Mr. Pacent predicted in a statement in the press that radio broadcasting would be done on as low as 10 meters in the future and then 25 to 50 stations could operate simultaneously within a small area without interference because of the extreme high frequencies at short wavelengths. It remains to be seen if Mr. Pacent's prediction will materialize.

As this brief biography is being written the Century Company of New York has published "The Complete Radio Book," of which the authors are Raymond Francis Yates, and Mr. Pacent. It is a most timely and meritorious book, in which the progress of the arts of communication before there were wires, then with wires, and now without wires, is traced historically and brought down to date. One rarely finds a technical work so broad and exact yet so clear and lucid in treatment and fascinating in style. Not the least striking and fascinating is the section that tells how Dr. Mahlon Loomis of Washington, D. C., as far back as the early

seventies, worked out a complete system of wireless through air transmitting a distance of several miles and patented his invention in 1872. The "how" and "why" of modern Radio is fully and completely set forth in this excellent manual, and there are many interesting items and chapters hardly to be found elsewhere—as for example a division of biography including the names and careers of some fifty of the men who have put "Radio" on the map as a great growing industry and art in America.

Mr. Pacent, although quite successful commercially, has an unselfish interest in the progress of the radio art. Characteristic of the products which he introduces is that there must be an actual unsatisfied need for them, regardless of the opportunity for profit which they may offer. His motto is "Improve communication and transportation and civilization will take care of itself."

Mr. Pacent has several hobbies. One of these is books, not alone on engineering, physics, mathematics, etc.; but he is also fond of good fiction. His greatest recreation is motoring and his interest in automobiles can probably be traced to his convictions in regard to transportation.



LOUIS GERARD PACENT

IRVINGTON VARNISH & INSULATOR CO., IRVINGTON, NEW JERSEY

The history of the successful development of Varnished Cambric, Varnished Paper and Varnished Silk to their present high state of efficiency and importance as materials in the electrical industry of the

C. P. BERGER

United States, is the life work history of the founder of the Irvington Varnish & Insulator Company, of Irvington, New Jersey; the late Carl Paul Berger.

The company was established by Mr. Berger in 1905, when the only available material of this character was cloth coated with oxidized linseed oil. With at first only a few coatings, the crude product was rapidly improved by scientific compounding of the varnish coating, until its demand necessitated immediate expansion of the producing capacity. The growth of the plant has been continuous and rapid, and has kept pace with the phenomenal growth of all branches of the electrical industry. Today the capacity of the plant is no less than ten million square yards per annum.

Varnished Cambric has numerous applications as flexible insulation in the electrical field, and is largely used for insulating motor and generator coils, and for transformer insulation; but the greatest bulk is used as cable insulation, both on power transmission cables and on ignition cables of various kinds. It was as cable insulation that Irvington's product established its superiority. Previous to and at the beginning of the Keokuk Dam project, on the Mississippi River, yellow varnished cambric had been used as cable insulation without much success due to the rapid deterioration of the cambric, and, consequently, the decreasing efficiency of the cable. Mr. Carl Berger had been manufacturing black varnished cambric, which was vastly superior to the yellow in its dielectric strength, heat resisting qualities and its slow ageing qualities; and this material finally superseded the former yellow varnished cambric in the Keokuk Dam cable, and gradually displaced the use of yellow varnished cambric entirely for insulation of power cables. Today it is universally used and recognized as standard.

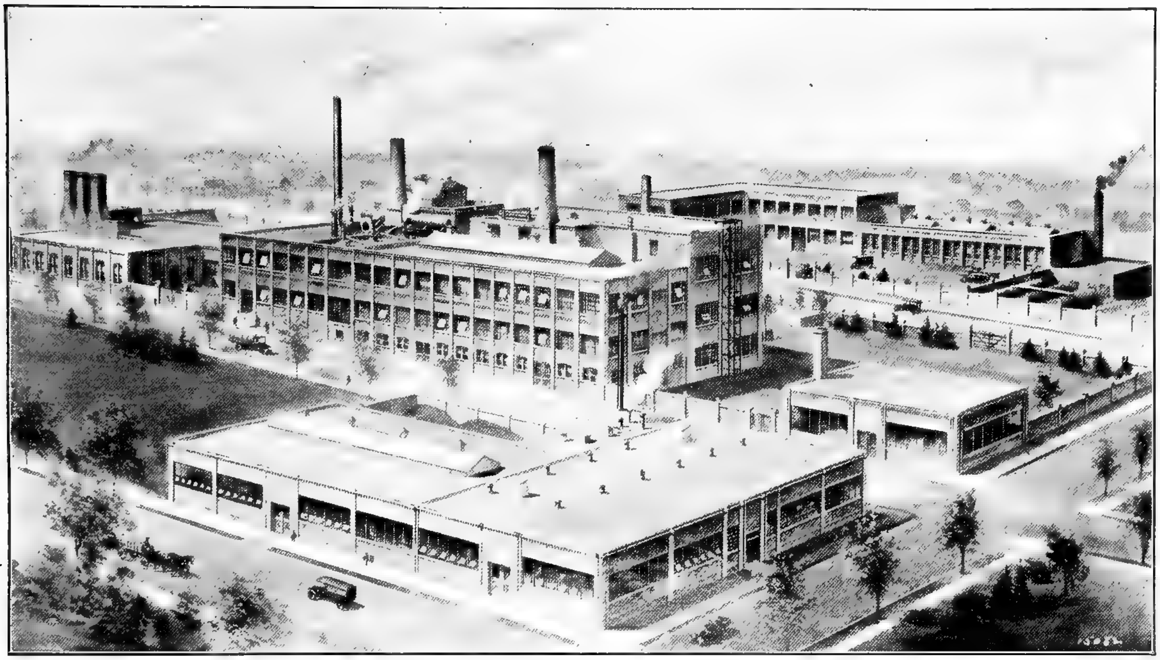
Before the World War, all the best varnished silk and paper for insulating magneto armature coils and electrical instruments was manufactured in Europe. Mr. Berger had been experimenting with the manufacture of these materials, and had perfected the process of making them as early as 1914; so that when the European source of supply was cut off, there was fortunately an immediate available supply for the United States and the Allies, to facilitate the airplane and truck transportation programs.

About 1916, the amount of cloth that had to be bleached and finished prepara-

tory to varnishing had attained large proportions, and there was no bleachery specially equipped to do that kind of work properly. It was therefore necessary to build a bleachery and finishing plant at Irvington, to prepare, under ideal conditions, the cloth for insulating purposes. The plant was started about 1916, and was completed in 1918, since which time it has been operating continuously, and has greatly improved the quality of the product turned out for insulating purposes. It is the only bleaching and finishing plant in the world that is devoted entirely to preparing cloth for electrical insulation.

The plant has always operated its own department for the manufacture of the varnish used in coating its product, so that today as the plant stands it is self-contained, dependent only on the world's markets for its raw materials.

It was in June, 1920, after seeing the completion of his plans, that Mr. Berger died, his untimely death being partially the result of the untiring effort and thought which he had put into this one interest that was both his work and his recreation.



Irvington Varnish and Insulator Co., Irvington, N. J.

However, in building up the business, he had built it well, and had established a world-wide reputation for the quality of his products and had developed an organization around him that was thoroughly trained in all the manufacturing processes. This organization has continued to function along the lines laid down by the founder himself; and even though there has been a change in the ownership of the stock of the company, the personnel has remained intact and is imbued as ever with the spirit of maintaining the same standard for the products, and aggressively developing new products and materials, as needs arise in the growth and ceaseless progress of the electrical industry.

THE PHOENIX GLASS COMPANY

From the loins of the electric light have been born a myriad of new industries. When that untrained power began to pour out its limitless force ways were sought and found to harness it for the use of man. A thousand things were needed for its control, a thousand more to direct its energies unwasted into paths of usefulness, and still another thousand to dress and decorate and temper its brilliance to the unaccustomed eyes of man.

In the last-named field a new era for the artist and designer was opened by possibilities that arose out of the electric light for commercial and domestic use. Here was an element that appealed to the artist and the craftsman in the vitreous and finer metal industries that for sheer beauty and flexibility was worthy of their greatest service.

One of the forces that was ready to set about this new work was the Phoenix Glass

PHENIXLITE No. 529
Dust-proof unit for all commercial lighting installations

Company of Pittsburgh, already organized and in the field as manufacturers of the globes and the necessary glassware for the lights that were then in use by the world.

The modern era of illumination marked by the birth of the arc and the incandescent lights which was to make obsolete

RADIANT NO. 555
Embodies all the desirable characteristics of Radiant Glass with an attractive shape added

many of the lighting accessories gone before, changed the destiny of this company and brought it into a new field as different from its original as the lamp chimney, with which it started, differs from one of its enameled, dust-proof, reflecting units of today.

For the purpose of obtaining some interesting and valuable historical data from the Phoenix Glass Company for this work, application was made to its management for the facts covering the growth and development of the business through the forty-odd years of its successful existence; the following two modest paragraphs was the result:

"The Phoenix Glass Company's factories are located in Monaca, Beaver County, Penna. They are incorporated under the laws of West Virginia. They

started in business in 1881. Their principal business at that time was lamp chimneys and opal domes for oil lamps. They later developed a line of globes for gas, and gas at that time was just coming to the front; and in the early 1900's they started to manufacture inner and outer globes for arc lamps, and also bulbs for the incandescent electric lamp.

"As the electrical period developed and broadened we increased our line of fancy shades for the electric fixture. The gas-filled and nitrogen lamps created a new field for illuminating glassware; in order to keep pace with the lamp manufacturers we produced a line of units in etched and toned glass, also enameled units to be used for public buildings, banks, churches, etc. Our plant has been enlarged from time to time until today we have approximately four times the capacity we had in 1900."

Plant of the Phoenix Glass Company, Monaca, Penna.

This concise story is written around a period which covers a greater development in lighting than all the centuries the world has known before and in that development the Phoenix Glass Company has played one of the principal parts.

Mr. Andrew Howard, who organized and owned the original company, is now dead. He has been succeeded as president of the company by his son, Mr. Thomas H. Howard. Mr. Alexander H. Patterson, now retired, who went with the company in 1885, and for over thirty years was its general manager, and Mr. E. H. Peck, the veteran sales-manager, who has been in charge of the vital end of the business equally as long and still remains at the head of the selling end, were in at the beginning and saw the great electrical illuminating business develop and were familiar with its every stage, and with the men of these times. Their shops and offices were open to the experimenter. The man with a new idea was welcomed, for wonders were on every hand.

The National Electric Light Association, organized in 1885, was never without one or two representatives of the Phoenix Glass Company at its every Convention. Many influential members of this Association will recall the days when conventions were perhaps more social than technical because its members scarcely understood what they represented, but the Phoenix Company's representative was never missing. And that applies to other organizations in the electrical family; none were too remote or too obscure to arouse the sympathy and support of this growing company. Thus, aside from the fact that the company is a leader in design, workmanship, and splendor of its products, it has the additional hold upon the electrical field that it was one to first plow the ground and to help with the seed that has ripened into so rich a harvest.

The factories of the Company at Monaca, herewith illustrated, are in the Pittsburgh District, celebrated in the thought of the world for its production of steel and no less for its glass factories. It is a location ideal for raw material, skilled labor, and ability in the administration of great industries, and for its facilities for immense distribution. The general sales offices of the Phoenix Glass Company are at 230 Fifth Avenue, New York City; the

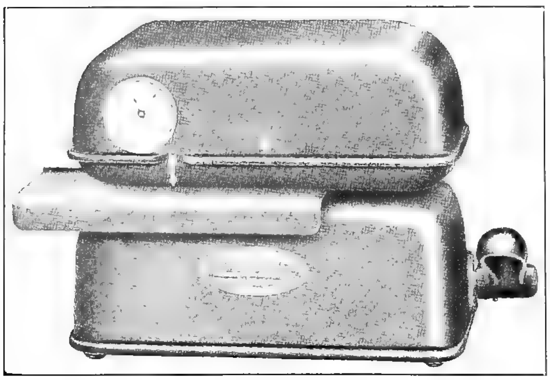
general offices are in Pittsburgh, while other offices in Chicago and Boston attend to the Western and New England districts, respectively. An export trade that reaches throughout the world is also enjoyed by the pioneer company.

STROMBERG ELECTRIC COMPANY

Electricity, with its manifold developments, has opened the way for so many and diverse lines of manufacturing that they are difficult to follow, but the Stromberg Electric Company of Chicago is engaged in one of the most attractive fields of all those which are founded in any way on electrical energy.

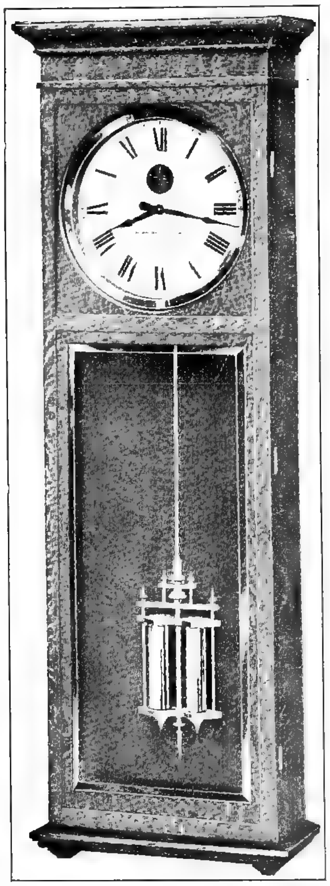
The name Stromberg is one which we often meet in the study of electrical development. It has been mentioned in other sections of this work and we again find it in connection with this company. His inventive genius entered into a number of lines which are leaders in present-day manufacturing.

The Stromberg Electric Company are makers of time-recording and cost keeping devices. As the value of Time has increased, it has become necessary for the owner of the modern factory, or business house, to know that his employees are giving him the quantity for which he pays. The necessity for recording time is fixed. Nothing is more easily understood than that conservation of time means progress —the only question to decide is the method or mechanism to be used in its measurement.



Stromberg Job Time Recorder for Cost and Production Systems

The Stromberg Company has done much for Industry with its constant propaganda for economy in the use of time. Labor—constantly working for shorter



Self-Winding Master Clock controlling the Stromberg System

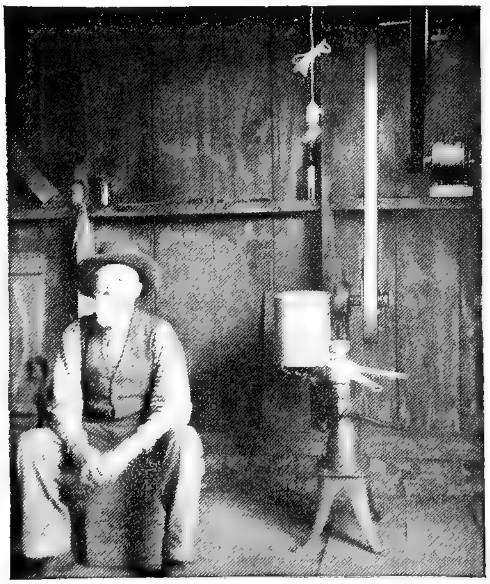
hours and a higher basis of pay—is better equipped with argument when the certainty of each hour is so faithfully measured. Time is the element upon which depends all costs and all production; its use and just how it is accounted for is the determining factor at the base of all work

and the pivotal point upon which depend profit and loss.

The Stromberg Electric Company belongs in the electrical field of manufacture because its entire system is built around a mechanism operated by electrical current. Its Master Clock which insures perfect synchronism of time throughout the entire system of which it is the head, is electrically operated, self-winding, and entirely automatic in operation. This Master Clock, which is a high-grade instrument, may be located at any convenient place where it serves as a time piece for the office or factory. The fact that it is connected electrically with the entire system, be it large or small, insures uniform time throughout the plant.

The company makes many types of time-recording instruments for all purposes, secondary clocks for observing time, time stamps for mail, telegrams, orders, etc., programme instruments for signalling or announcing time, all of which are connected with the same circuit and controlled by the Master Clock. The efficiency of this service is demonstrated by customers who are using several hundred instruments in a single system and others using only one or two. Time is valuable to all of them.

The main office of the company is located at 209 West Jackson Boulevard, Chicago, and it has branch offices in a score or more of the largest cities throughout the United States and Canada.



"A Seasoned Electrical Enthusiast"

A BRIEF HISTORY OF STONE & WEBSTER, INC., AND A REVIEW OF THE PROGRESS AND ACTIVITIES OF THAT COMPANY

The career of Stone & Webster is particularly interesting because it practically synchronizes with the entire history of public utilities, with the exception, of course, of the steam railroads, the telegraph and the telephone. The arc light had been in use about fifteen years before they began business, but the incandescent lamp had just come in, while the use of the electric drive in industry was still a thing of the future, as was also the long-distance transmission line.

In 1884 Charles A. Stone and Edwin S. Webster entered the Massachusetts Institute of Technology, and were graduated in 1888, together with a number of other men now prominently identified with the Stone & Webster organization. In 1889 they formed a partnership and started in business as consulting electrical engineers at 4 Post Office Square, Boston. Their first work was laying out wiring, designing small plants and performing electrical testing, for which they were equipped with a few instruments. Their two small rooms were occupied by themselves, a stenographer and one or two draftsmen. Today their forces occupy an eight-story building in Boston (two new stories are now in process of construction), as well as several floors of a large adjacent office building, and offices also in New York and Chicago.

In 1891 Stone & Webster were engaged to plan a power transmission plant at Cumberland, Maine, for the S. D. Warren Paper Company. There were then very few transmission plants in the United States, and alternating motors were hardly known. A successful alternating current plant was installed, however, these young engineers designing what was then the longest transmission line in the country, though today it would be considered a trifling affair. The firm soon became engaged in the construction of a number of large power houses, notably in New England and the Middle States, as far south as Tennessee. It was at this period, too, that a power plant was installed for the Massachusetts State House, in addition to a large amount of work done for various city departments in Boston.

During this period many electrical enterprises sprang up in different parts of the country. In view of the fact that the electrical profession was then in its infancy and that most of the methods to which it has owed its marvelous development were undevised, and in view, also, of the fact that the country was heading toward the panic of 1893, it is not surprising that a considerable portion of these industries eventually found themselves in difficulties. It will be recalled how drastically the steam railroads of the country had to be reorganized as a result of the 1893 panic, and it is no wonder that the electrical industries were to a degree subjected to the same condition. In many cases, the holders of their securities were forced to recast these industries in accordance with the best engineering skill then obtainable, and in accordance also with the best financial skill. The owners of such properties began to employ Stone & Webster to make investigations, to advise regarding additional expenditures, and to outline reorganization plans. The firm made hundreds of examinations, and in this way accumulated the experience which constituted the foundation for its later activities, which have comprised financing, designing, constructing and managing public utilities of every description.

Beginning with investigations and reports for others, Stone & Webster soon began to investigate, reorganize, finance and manage properties on their own account. As the management of one company after another was acquired, large permanent staffs were necessarily built up. Experts in many lines of work—designing, construction, the management of railways, central stations and hydro-electric plants, and financing operations—were added to the organization at an accelerated pace.

Such was the evolution of the Stone & Webster Engineering Division, the Stone & Webster Management Division and the Stone & Webster Securities Department. These are the larger divisions, but there is also an industrial department which has charge of a number of industries other than electric, a laboratory, a library, and the publication office of the *Stone & Webster Journal*.

A general idea of the growth of the Stone & Webster organization may be obtained from the fact that the latest figures show it as managing about 80 public utility companies, capitalized at about $228,000,000, with gross annual earnings of more than $40,000,000. As the activities increased, new partners were added, in every case from the organization itself, the list comprising on January 1, 1920, Charles A. Stone, Edwin S. Webster, Russell Robb, Henry G. Bradlee, Frederick P. Royce, George O. Muhlfeld, Henry B. Sawyer; Frederick S. Pratt, Harry H. Hunt and Howard L. Rogers. A few weeks ago the firm was incorporated as Stone & Webster, Inc.

Stone & Webster have built many of the largest power stations in the United States. At present the firm is engaged in the erection of a number of great structures of this description, notably that of the Philadelphia Electric Company. Stone & Webster have constructed some of the largest hydro-electric plants in the United States, among them that of the Mississippi River Power Company at Keokuk, Iowa (which is, indeed, the largest development of its kind in the world), with its 150 mile transmission line to St. Louis, each tower of which is in itself a notable feat in engineering and construction; the Big Creek development of the Pacific Light & Power Corporation in California, which was originally designed for 40,000 kilowatts, but was actually completed as a 60,000 kilowatt plant and has a transmission line of 120,000 kilowatts to take care of future extension; and the Snoqualmie, the White River and the Electron developments in the Puget Sound district.

In the limits of this brief article, it is impossible to enumerate the work done by Stone & Webster in constructing and developing electric railways, and it is also necessary to speak, merely in passing, of the numerous office and other industrial buildings, large and small, which have been built in various parts of the country. A word should be said, however, of the war activities of the organization. Several months ago, the War Department of the United States issued a citation of merit to Stone & Webster, in which it enumerated the signal services of the organization to the United States Government "in obtaining victory of arms in the war with Germany and Austria."

The major part of the work of building camps and cantonments was completed during the summer and early fall of 1917. In addition to sixteen cantonments for the men of the national army, distributed throughout the country, the construction division of the Quartermaster's Department was called upon to provide sixteen national guard camps situated in the South, as well as aviation camps, balloon schools and the like. Stone & Webster carried out construction of camps in all these divisions. The first work was undertaken early in July, 1917. Before the first of October, the organization had completed and turned over to the Government accommodations for about eighty thousand troops of the national army, national guard and aviation service. These contracts included the national army cantonment, known as Camp Travis, and the aviation camp and training school, known as Kelly Field, both at San Antonio, Texas; the national guard camp, known as Camp MacArthur, and the aviation camp and training school, known as Rich Field, both at Waco, Texas. In addition, a balloon school, one of the three schools of the kind called for by the Government, was built at San Antonio, Texas.

The greatest public interest, no doubt, attached to the building of the national army cantonments for many reasons, not the least of which was the publicity given the competition among construction firms for the completion of their respective contracts. Periodical bulletins, comparing the progress of the contracts, were posted at the Quartermaster General's Office in Washington and published in the daily

news dispatches. Camp Travis was prominent in this race and the dispatch after the posting of the final bulletin on September 13th read: "Stone & Webster stand at the head of the list with 99.7 per cent. of their work done." Camp Travis was also the least costly of the sixteen cantonments on the basis of over-all cost and very nearly the least costly per capita based on the quotas of troops accommodated. On the per capita basis Camp MacArthur, among the first of the national guard camps to be completed, was also very nearly the least costly. It is perhaps unnecessary to draw attention to Kelly Field, not only as the largest aviation camp, but also as the pivotal feature in the entire program of the Government for training army fliers.

In the division of supplying arms and munitions, Stone & Webster's work took the form of extending and modernizing three arsenals in this country and constructing the ordnance base depot for the American Expeditionary Force in France. Much of the arsenal construction, particularly at the Watertown and Rock Island arsenals, was of a permanent character. In all, 167 arsenal buildings were erected. At Watertown the four largest buildings had an average length of about 600 feet and an average width of about 150 feet. At Rock Island the work included the new Field and Siege buildings, one of which is a large reinforced concrete structure with a fine architectural rendering in concrete, making it unique, perhaps, among all the buildings built by the Government under the duress of war.

In August, 1917, Stone & Webster were selected for the construction of the ordnance base of the American Expeditionary Force in France. This work included the layout and detail design of buildings and equipment, purchase of structural materials, supervision of the erection of the buildings, and the purchase and installation of machine tool equipment. The plan originally called for a single group of buildings covering 100 acres of floor space at Mehun, with units for repair artillery, small arms, tractors and personal and horse equipment for reloading artillery ammunition, and for the storage of material and parts. This plan was modified by breaking up the plant into seven groups located along the line of communication from the debarkation ports to the front, Mehun remaining the main base. Of the material required for the plant, amounting to 58,000 tons, about 5,000 carloads, or 80 per cent., had arrived at destination in France before the armistice. Parts of the plant were in operation and the completion of the entire work was a matter of a very short time.

A word should be said of another great Stone & Webster war activity. In the third of the country's great war requirements, that of ships, the design and construction of the Hog Island shipyard and 120 vessels under Stone & Webster supervision measured the extent of the service provided by the organization. It is, perhaps, somewhat indicative of technical resources that the Hog Island shipyard and the ordnance base in France, both among the Government's largest projects, were undertaken and carried through, at one and the same time, by organizations drawn from the home office of Stone & Webster.

The contract for the Hog Island shipyard was undertaken September 13, 1917, and the first vessel was launched August 5, 1918. In this period of less than eleven months a strip of isolated tidal marsh on the Delaware River was transformed into the world's largest shipyard with fifty ways and outfitting berths accommodating twenty-eight ships at a time. The plan of the fabricated steel ship was worked out and the steel mills and scores of plants throughout the country were lined up and put to work producing parts in time to meet the ship production schedule at the yard. Within twenty months of the first launching, eighty-three ships had been delivered to the Government, and these ships had steamed a total of 1,500,000 miles. It is a marine record without parallel.

Such, briefly, is the history of Stone & Webster from its humble beginning, through the various stages of its development, to the pinnacle of its present organization of national and international fame.

THE SPAULDING ELECTRIC COMPANY

Realizing the need of an electrical repair shop capable of handling all repairs and maintenance of power apparatus in a city which was rapidly becoming the leading manufacturing center of the United States, Mr. J. G. Spaulding, in 1910, with limited capital but unlimited enthusiasm and ability, established a small shop on a side street in Detroit, with the object of meeting this want. While the shop was small and the location remote, the old proverb says that if you have what the world wants it will make a path to your door even in the heart of the forest, so Detroit came to the little basement shop; and because it always received a square deal, efficient service and results, it continued to come, and the business grew.

In 1911 the demand for new electrical machinery became so great that it was necessary for Mr. Spaulding to organize a sales department and he therefore secured the agency for a standard line of power apparatus. In 1913 business had increased to such proportions and the work of the shop and its policy of doing business had made such a name for itself, that the old quarters were found to be entirely inadequate. A more commodious location was therefore sought with the result that the shop and office were housed in a three-story building just off Michigan Avenue. At this time the business was not large enough to require all the space afforded by this new location, so the upper floor was rented to another manufacturing concern. However, automobile manufacture was then growing with such leaps and bounds that it was not long before business for the motor repair shop had increased to such an extent that it was necessary to occupy all three floors, the third floor being used for a stock room.

In 1918 it was found necessary to again increase the quarters and the offices were moved to another building facing on Michigan Avenue. This building also housed a small retail store which it was found necessary to establish in order to supply the demand for accessories such as lamps, fuses, switches, etc. In 1920 the repair business had grown to such proportions that the shop required all three floors to handle the increased volume of work, and a steel warehouse building was constructed between the shop and the office and store building.

During this entire period of change, and in spite of the rapid growth, Mr. Spaulding equipped his plant with the best and most up-to-date machinery necessary to maintain its reputation for prompt service and to insure entire satisfaction to all with whom he had dealings. At the same time, in keeping with the policy of square dealing, everything possible has been done for the comfort and welfare of employees. All this makes for efficiency, and as a result the Spaulding Electric Company maintains an electrical repair shop which is second to none in the great manufacturing center of Detroit, and produces work and service in such a way that its reputation is wide-spread and enviable.

THE SUN-LIGHT ARC

The Sun-Light Arc is the brightest source of light available at the present time. It is more than an improved arc-light—in fact, it is a radically new source of light. The Sun-Light Arc, which is also known as the "High Intensity Arc" is over 400 per cent brighter than its nearest rival, the ordinary carbon arc.

Ever since the discovery of the electric arc by Sir Humphry Davy, over one hundred years ago, the positive crater of this carbon arc has been the brightest source known, and up to the development and perfection of the high intensity arc, it was considered that the carbon arc brightness was the limit of what could be produced. Practically all of the very bright sources of light have been produced by incandescent solids,—for instance, the tungsten filament of an incandescent lamp, or the solid carbon crater of an arc lamp. The Sun-Light Arc has surpassed all of these in brightness, by the utilization of a gas or vapor as a "brightness" producer, instead of a solid. Special positive electrodes are used, which form when burning a very deep crater and which supply this crater with brightness-producing vapors. The deep crater, filled to over-flowing with these vapors, gives an illumination which was considered only ten years ago as impossible of attainment.

Speaking in terms of figures, one square mm, or say roughly one pin-head of the ordinary carbon arc crater gives a brightness of about 150 candle-power. One pin-head from a 900 watt tungsten incandescent lamp gives only about 25 candle-power. One pin-head from the crater of a Sun-Light Arc gives over 700 candle-power. On this scale, even a corresponding area of the sun at high-noon gives but a little over 900 candle-power, or only slightly more than the crater of the Sun-Light Arc.

It is not surprising in the least, that such a radically new source of light should prove revolutionary in the motion picture field. Motion pictures, as an industry, are perhaps the greatest light users of all industries, and hence this arc has played a very important part in the development of motion pictures in the last few years.

Along with the tremendous increase in brightness of the arc, there is also a great increase in actinic value. This is so great, that for the same intensity of visible light from the noon sun and from a Sun-Light, the arc will have over three times the photographic value of the sun. The makers have given the motion picture producers what they had long sought—portable sun light, and they are now using these units for just this purpose.

When motion pictures were first made, everything was photographed out-doors in the real sun light—even the interior sets were built out of doors without roofs. As the industry grew in magnitude, big glass-roofed studios were put up, and the sets were built under these glass roofs, facing in the proper direction, so that at some time of the day the sun would shine on them at the right angle for taking pictures. Cloudy and rainy weather, and the short hours of sun light, made the operation of these studios very expensive. In the last two years, since the Sun-Light Arc Corporation has provided artificial sun light, not a single one of the new studios has had a glass roof, and many of the old glass-roofed studios have obscured the glass with black paint.

But the advance has gone even further than this. Whereas it used to be customary to take even interior scenes out of doors, motion picture directors now actually prefer to take many of their exterior scenes indoors, and the work is done with such perfection, that it is difficult to detect what scenes were taken out of doors and what were built and taken indoors.

A short time ago, a motion picture producer in New York City built in one of the huge armories of the city a very complete set of New York's East Side, including buildings, pawn-shops cobble-stoned streets, and even a full-sized trolley car, which was rented from the city. When the set was ready to be photographed, the director brought up from the East Side several motor truck loads of men, women,

J. JUSTICE HARMER

push-carts and children, picked up right out of the streets, and paid them well for parking their push-carts on an artificial street. At first such a plan seems extravagant, but it has proved many times to be a great money saver in being entirely independent of the weather, curious crowds, interfering city officials, etc.

The above gives only a limited idea of what the contribution to this field has accomplished. It is now quite impossible to see any feature motion picture which does not have many striking and beautiful sunlight effects, all of which have been produced under the Sun-Light Arc.

But this only includes one-half of the lighting needs of the motion picture industry. Bright light is needed for two separate and equally important purposes. The first, just described, might be called the producer's or studio lighting. The second use, equally important, is the exhibitor's or theatre projection lighting. It is perhaps not realized how much light it is necessary to send through the little motion picture film, measuring only 1 in. x ¾ in., in order to have that picture magnified nearly 100,000 times, as it must be on the screens of the larger motion picture houses, and still have sufficient illumination to do justice to the beautiful motion picture photography of the present day.

The Sun-Light Arc has again come to the rescue of the industry by making available to the theatres a method of increasing their screen illumination to twice what they could obtain by the old methods with the carbon arc. A rather serious limitation had been experienced in large theatre designs a few years ago due to the fact that it was impracticable to obtain enough light on the screen for good projection by the old methods; and it appeared that this lack of light was going to be a real restriction in the size of theatres. The Sun-Light Arc applied to projection has now made it possible to give the most satisfactory pictures in the largest houses yet constructed and has also removed the limitation for the construction of still grander motion picture theatres.

The Sun-Light Arc Corporation of 1600 Broadway, New York City, naturally occupies a position at the head of the "Great White Way" as it literally does the center of the stage in the motion picture art. It was organized January 18, 1918, by Mr. J. Justice Harmer, who is president; and the other officers are as follows:—J. Searle Dawley, vice-president; Walter E. Haskin, secretary; W. F. Ashley, attorney; and Carl G. Nesbitt. Its capitalization is $1,000,000. Its main aim is as already noted above, but it finds a demand for its product also in general stage lighting and "spot-lighting" for the theatre; in the reproduction of art by photography, lithographing and photo-plate making; in fire department work, in advertising by illumination, as of signs and bill-boards, in mining and in railroading. Even these great fields do not limit the application of the Sun-Light Arc.

Mr. Harmer comes very naturally and by evolution to his success in this work. At the early age of ten he entered the printing office of the Centennial Advertising Company, in Philadelphia, and for over forty years has followed and led the development of the graphic arts, being a recognized expert in the reproduction of fine color work and internationally known in the technical departments of the graphic arts and processes. In 1910, owing to these specialized studies, Mr. Harmer became interested in "offset" or plain surface printing and intaglio, and created a number of methods for plain surface plate-making, associating photography with pictorial design. At this stage, the thought came to him and his associate, Mr. Vincent Lake, of typographical composition by photography—i.e., photographing a single character at a time in the sequence of the spelling of the work. Quite a novel conception in both typography and photography. In order to get the desired result successfully, it was necessary to have parallel rays, and Mr. Harmer had been working in this direction, when he met the famous electrical engineer, Elmer A. Sperry, who gave him a demonstration of his Sperry Arc Light, in which Mr. Harmer recognized at once the means of securing full color value. In other words, in the perfected Harmer invention, from that point of departure, color has had as perfect definition in the Sun-Light Arc, as under the sun itself. Needless to say, this

has not only recreated motion picture production, but has revolutionized photography itself, as to color.

After making a success in the line indicated, Mr. Harmer entered the domain of projection. As far back as 1917, he asserted that all the photography in the films was not being thrown onto the screen, due to the lack of light and the color inadequacy. With the co-operation of the Sperry talent, Mr. Harmer began to develop what is now known as the Sun-Light Arc High Intensity Projection Lamp for the purpose of picture projection, and although the appliance has been on the market only a few months, it has already made its own place. By both photographing with Sun Lights and projecting by them, the atmospheric conditions involved are, so to speak, thoroughly synchronized and harmonized; and it is noticed that there is an ensuing stereoscopic effect secured on the screen, worth all the long period of hard work and the expenditure of large sums of money before the goal was reached.

Unique example of Electrical Illumination as demonstrated on the Washington Monument

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